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The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

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A Better Perspective

Mr. MacDougall's excellent Paper, printed elsewhere in this issue, is capable of misinterpretation by the careless student, because of the *modus operandi* of the experiments. The author's earlier experiments were carried out with a view to ascertaining whether, *inter alia*, cupola compositions would be ameliorated by superheating in the electric furnace. The fact that negative results were achieved is not of great importance; rather should the following factors be emphasised. The electric furnace permitted of two things to be done. The first is that the desired compositions could be easily attained, emphasising initially the ease of control to be associated with the electric melting process. The second was the ability to superheat. That no radical improvement was shown by the methods chosen for revealing the various properties came as no surprise to us, but we were impressed with the control which afforded such close comparisons to be made. The reverse proposition, that is, to reproduce a high-grade high-duty iron made in the electric furnace by the cupola process, is by no means so easy, and this factor does stress the inherent advantages of the newer process. To take the case a little further; should the conditions for the creation of an iron of outstanding worth be postulated for a certain cupola plant, it is by no means sure that the prescription can be followed with a certainty of success in a similar furnace installed in the foundry next door. With the electric furnace, however, no such doubt exists. The position is thus quite clear, and if material advantages are to be gained by superheating, then the electric furnace process is ideal for their practical realisation, and it is no fault of the actual furnace if experiment shows that the benefits sought are nebulous. For experimental purposes, the electric furnace is of outstanding worth, and is obviously capable of producing irons possessing just those properties most sought after by engineers; but it is unable, and there is little likelihood of its ever being able, to melt iron as cheaply as the cupola. Therefore, it appears to us that it might be as well to take the electric furnace for granted; use it for the creation of special irons, and then seek to reproduce the results obtained in the cupola, with the obvious object of doing the same job more cheaply. Whilst business conditions are good within the foundry industry we would like to see a maximum number of electric, pulverised-fuel and oil-fired rotary furnaces, cupolettes and crucibles installed, because of their undoubted influence on metallurgical control in their initial stages. When dressed in a new suit, a man usually hitches up his pants to preserve the crease—later he is not so particular. The average executive treats new plant similarly, with a maximum of advantage to the control of the product.

Green Sand

During the meeting of the London Branch of the Institute of British Foundrymen recently addressed by Mr. Fassotte, reference was made to the use in steelfounding of a sand with a greenish tinge, and the suggestion was made that this might account for the origin of the term "green sand." Sands containing mineral particles conferring a green colour on the mass are occasionally met, and such materials as glauconite will do this, but their comparative rarity suggests that the connection with the term "green sand" is accidental rather than real. The term green sand probably dates from the very earliest days of the moulding art, and it seems unlikely that these unusual sands were used in those days. While some historical investigation would be needed to settle the point, it is more probable that the earliest sands used in this country were red.

On the other hand, there is ample evidence in our common expressions of the use of the term "green" to imply the state of being raw or unseasoned, or not dried. Thus the beginner or one who is ignorant is termed a "greenhorn," or green hand. Unseasoned wood is termed "green wood," quite without regard to its colour. We speak of a "green old age," when we refer to those with vitality and lacking the withered or dried aspect of the aged. From the term "green wood" we have the term "green stick fracture" of a youthful bone that bends before it is completely fractured. "Green cheese" is unripened cheese before it has been matured. In these and in other illustrations we constantly come across the use of the term "green" in a sense which makes it a perfect opposite to its foundry counter number, dry sand. This seems to make it unnecessary to look for more fanciful, if superficially more correct, designations. If we consider that both this country and Germany may lay claim to having developed the art of founding in Europe, there is nothing in German to suggest that the word for moist sand has any special colour connection. The dictionary of foundry terms, when complete, will help in settling points such as this, and the examination of other practical foundry terms may throw interesting light on the origins of the craft which would be sought in vain in the records of the past.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Defects in Chilled Rolls

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—We are manufacturing chilled rolls of 330 mm. diameter and 800 mm. long, for our steel-plant rolling mills. In the majority of castings produced, we are meeting with chill crack troubles. The rolls crack either longitudinally (throughout, or in some cases at the bottom) or circumferentially, and in some cases at the neck, while under similar procedure adopted, we are getting good rolls also. Various experiments have been attempted, but with no uniform results.

We give here some facts regarding our manufacturing experiments:—

(1) The chill die thickness is kept 6 to 7 in. Tapered grooves, four in number, are also provided. The die is supported, perfectly level, with the axis of the bore perfectly vertical.

(2) Cracks appear both when bottom pouring with a tangential runner, or top pouring with a central runner, is adopted. The size of the down runner is varied from 1¾ to 2½ in. dia.

(3) Both hot pouring and cold pouring have been attempted. The following analysis is maintained by the use of charcoal pig-iron: Si, 0.8 to 0.9; Mn, 0.4 to 0.8; Cr, 0.4 to 0.5; Ni, 1 to 1.2; T.C, 3.0 to 3.2 per cent. Alloy additions are made inside the cupola along with charges, in packed tins and also at the spout. Cracks appeared even when ordinary pig-iron and steel-scrap mixtures with Si 0.7 to 0.9, Mn 1.1 to 0.8, and T.C 2.9 to 3.2 per cent. were used.

(4) The chill die is removed 25 to 30 min. after casting as well as after 35 to 60 hrs. of annealing inside the chill.

None of the above procedures adopted relieved us from the crack troubles, especially whenever deeper chill depths in the rolls to the extent of 2 to 2½ in. were adopted. Can any of your readers put us in the way of locating troubles and enlightening us with complete successful manufacturing details?

Yours, etc.,
B. RAMASESHIAH, B.E.
(Superintendent, General Foundry).
The Mysore Iron and Steel Works
(Government of Mysore),
Bhadravati (India).
November 12, 1937.

Sand Testing

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—As I am, at the moment, very much interested in the relative merits of the A.F.A. and B.C.I.R.A. test-pieces for sand testing, I would like to make a few remarks on an article by Mr. J. Dearden, B.Sc., etc., in the JOURNAL, which deals with the subject.

(1) Mr. Dearden is wrong in supposing that the B.C.I.R.A. method was intended to be used at a single apparent density, with variation of moisture or anything else, and if he used that system he cannot expect to get any reasonable results.

(2) He says: "As water can only take its place in the void spaces it must reduce permeability." Now moisture does not always reduce permeability, for example, 6½ per cent. water gives permeability No. 130 A.F.A., while 12½ per cent. water gave permeability No. 140 A.F.A. in Scottish moulding sand. Others can be quoted, but this is sufficient to dispose of his main reason in favour of the A.F.A.

(3) Higher strength of A.F.A. test-piece is due to two causes or errors; (*a*) uneven ramming which gives a hard centre which is ABOVE the average strength of the test-piece; (*b*) to the diameter of the test-piece being too large —1 sq. in. area is the largest that can be allowed for a 2 in. length of test-piece.

(The writer is expressing the result of extensive personal research on this point, and is not quoting from text books.) These combined errors, (*a*) and (*b*), cause the A.F.A. test-piece to give strength readings about 50 per cent. high on Scottish moulding sands for example, and unfortunately this combined error varies with moisture, clay content and grain size.

(4) Mr. Dearden's remarks on the double compression test-piece being hard at both ends and soft in the middle are also wrong, as I have proved at great length and put before the Institute years ago.

(5) Clay density is given as 1.25 to 1.30—this should read 2.70 (true density).

(6) Errors in weighing need not be continually brought against the B.C.I.R.A. test-piece. A reasonably good balance and a properly-trained operator will put this right if it exists at all.

Finally, the A.F.A. test-piece was never intended to be made with more than 3 blows, and this is a poor substitute for the double-compression method for testing range of densities.—Yours, etc.,

WM. Y. BUCHANAN
(Metallurgist & Foundry Manager,
John Lang & Sons).

Lifting Loops for Cast-Iron Ingot Moulds

A particularly handy tool for bending to shape the wrought-iron loops for cast-iron ingot moulds is shown in Fig. 1. The loops are shown in their respective positions in the ingot mould. The size of material used for this work varies according to the mould dimensions, and in this case it is 1⅛ in. in diameter, and is first of all cut in cold sheared lengths of 21 in.

The tool shown in Fig. 1 consists of the wrought-iron forged bending block *a* and the

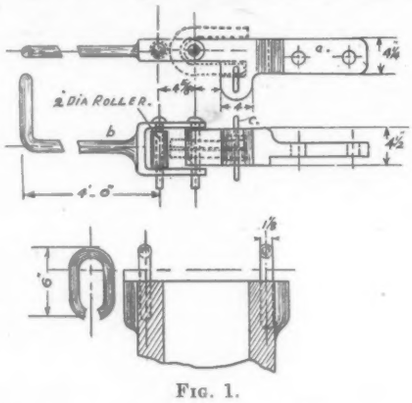


FIG. 1.

bridle *b*. The bridle is first brought to a position at right-angles to the bending block. The material or bars referred to are now fixed in pairs in the position indicated by the dotted lines and held secure by the cotter-pin *c*, which is driven home. The bridle is now pulled around, after which the pressure is released on the lever and the cotter-pin withdrawn. This part of the operation is now complete, and all that remains to be done is to hammer over the two extreme ends as shown.

Many thousands of the loops have been made satisfactorily by this method, and incidentally this tool has been found to be very useful for many other jobs.

THOS. W. WARD, LIMITED, Sheffield, have purchased the "Blue Peter," a vessel of 4,132 tons gross, from a Newfoundland firm for breaking up.

Random Shots

The price of milk has recently gone up to 7½d. a quart, and the price of the JOURNAL is soon going up to 6d. Nobody minds the advance in the price of milk (speaking from purely the man's point of view), and surely there is none with soul so mean that he begrudges the extra penny on the JOURNAL! Some time ago, a Scotsman, mark you, wrote to the Editor suggesting this very thing, for "mon, it's worth it" wrote he. But lest anyone should think that the present increase in price is a result of that advice from the other side of the Border, let it be made clear that it is the advance in the cost of printing and paper that is to blame. How well manufacturers of foundry goods will understand that ever-present bogey—the cost of raw materials! Now, Junior wants to know if Father can buy his comic at Woolworth's!

* * *

Recently someone proposed that there should be an entrance fee prior to membership to the Institute of British Foundrymen. And why not, pray? The astounding thing is that there has not been one hithertofore. Most other technical societies demand one, so do many of the gentlemen's clubs. There is an entrance fee to any good tennis club, and there is even one to the annual church bazaar and the vicar's garden party!

* * *

When is a pig not a pig? The foundryman will at once say "when it is a sow." But that is not necessarily so, for a little pig has the great distinction of having more local names than all the other pigs put together. In Lincolnshire they call the smallest pig of a litter "the reckling." In Cornwall it is the "Piggy-Whidden." In the Glamorgan district it is the "Crank," in parts of Scotland a "Coacher," in Suffolk they call it a "Tidman," whilst in Somerset it is a "nestle-tripe." It is left to Mr. Kain and Mr. Booth to say what they call it in Essex. Imagine, then, a complaint from a foundry in Somerset to its pig-iron supplier: "Dear Sir—Your last consignment of pigs was definitely nestle-tripe. If this is the best you can do, in future please send sows." Junior, knowing none of these names, merely calls his youngest cousin "a little pig," and quite naturally follows out the same metaphor, allowing for age and sex, when talking of his school matron.

* * *

JUNIOR: Did Edison make the first talking machine, Father?"

PARENT: "No, son. God made the first one, but Edison made the first one that could be shut off."

* * *

French without tears. This week's dose:

(1) La vertu—feminine.
Le vice—masculine.

Draw your own conclusions.

(2) Métallique, the feminine of which is métalliquette.

If the penny hasn't dropped make a note of it for your next visit to Paris.

"MARKSMAN."

Corby Rolling-Mill Plant

Stewarts and Lloyds, Limited, and the Lancashire Steel Corporation, Limited, which in August last formed the Lancashire & Corby Steel Manufacturing Company, Limited, for the making of rolled products at Corby, have now registered a company to undertake the selling of the manufactures. It is called the Lancashire & Corby Steel Selling Company, Limited, and has a capital of £50,000 in 25,000 "A" ordinary and 25,000 "B" ordinary shares of £1 each. Semi-finished steel will be supplied by Stewarts and Lloyds. The Lancashire Steel Corporation will control the manufacture of the finished products.

High-Duty Iron

SOME EXPERIMENTS WITH THE ROCKING ARC FURNACE*

By B. MacDOUGALL

It should be clearly understood that the conclusions reached in this Paper are taken from the results obtained up to the present only. Further experiments have still to be carried out to fill in obvious gaps and to finish certain series of experiments, and it is hoped at a later date to be able to complete this study.

The experiments were commenced with a view to ascertaining the conditions governing the production of cast irons unalloyed and alloyed, from an electric furnace, which would give either all or several of the properties listed below in the highest degree:—(1) Soundness; (2) machinability; (3) ultimate strength; (4) resistance to impact; (5) resistance to wear, and (6) resistance to volume changes and distortion under heat influences.

The most important of these properties is undoubtedly soundness, since a casting becomes valueless unless it be free from shrinkage defects, blowholes, slag inclusions, cracks, etc. Similarly, with machinability, unless a casting be free from hard spots and be sufficiently low in hardness value to allow of easy machining, its usefulness for general engineering work is negligible.

The first of these properties depends to a greater or less extent on practical foundry technique which, by giving proper attention to gates, sprays, risers, condition of sand, method of casting, casting temperature, etc., should with ordinary care result in a sound product. The second, on the other hand, depends on the chemical analysis of the metal and the thermal condition, *i.e.*, casting temperature, metal thickness and method of production, whether green-sand, dry-sand or chill casting. The correct balance of these conditions with metal analyses should produce an easily machinable casting. Since the thermal condition is of such great importance, it should here be pointed out that throughout this Paper all the results are taken from British Standard Specification 1.2 in. diameter bars, 21 in. long, which were machined for tensile test without any heat-treatment to 0.65 in. diameter, *i.e.*, ½ sq. in. area. These bars were produced in oil-sand cores 3 in. square which were inserted into a 6 in. diameter tube and rammed with a backing sand, three tests being taken per experimental heat of 300 lbs.

Assuming the properties of soundness and machinability, high-grade cast iron has commonly been defined on the basis of strength property, since there is a broad relationship existing between this property, growth and wear. This statement is made in its broadest sense, since any feature of composition, constitution or treatment which influences one or other of these related properties is likely to have a similar effect on the remaining properties. For example, much has been written on growth and irons with low silicon content. Assuming the machining property, tensile strength and wear are also compatible with low silicon. Similarly, with low total carbon, it is known that the tensile strength is improved, while wear and growth are not impaired, but in some cases are even improved. In these experiments, therefore, high-duty iron will be considered solely from the point of view of improving the tensile strength, it being assumed that the other properties, *i.e.*, wear and growth, are related.

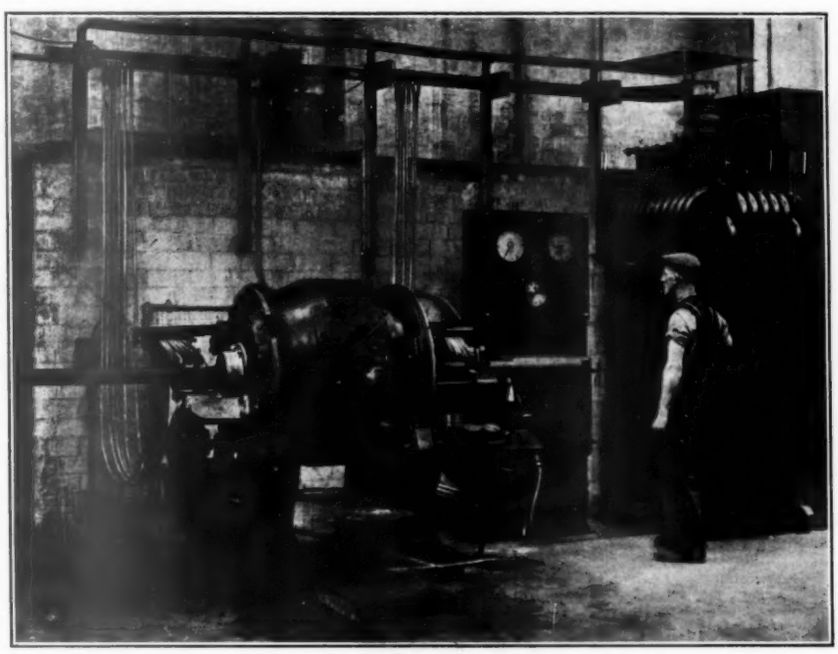


FIG. 1.—ROCKING ELECTRIC-ARC FURNACE IN WHICH THE EXPERIMENTS WERE CARRIED OUT.

The Furnace

The furnace (Fig. 1) installed for these and subsequent experiments is of the single-phase rocking arc type of rated capacity 350 lbs. cold charge and 500 lbs. liquid charge and a power input of 125 kw. It has a horizontal cylindrical body, on the axis of which enter two graphite electrodes. This cylindrical body is lined with rammed sillimanite, although it is agreed that for grey-iron melting this is not the best. This body is arranged to rock through a varying angle about its horizontal axis, an ingenious automatic rocking control device being supplied to facilitate operation. By means of this device, rocking can be maintained at a definite angle between 20 and 260 deg. or arranged to increase through varying angles at fixed periods.

The advantages of rocking are longer lining life and quicker melting, due to the fact that the metal is in direct contact with practically the whole of the lining during the molten state, thus absorbing heat from the lining, and maintaining a uniform heat balance between the metal and lining. The factors contributing to the selection of an electric furnace for the production of high-duty iron may be summed up as follows:—

(1) Uniformity and control of chemical analysis. No sulphur or carbon pick-up.
(2) Ability to give high degree of superheat.
(3) Ease with which alloy additions can be made.
(4) Only small quantities about 1,000 lbs. of metal required at one time on any day.

It is not proposed to enter into the cost of operating this type of furnace for two reasons. Firstly it is beyond the scope of this Paper, and secondly, since the furnace has been operating intermittently, and under varying conditions, it has not yet been found possible to estimate accurately what the cost will be on a production basis.

Effect of Superheating Ordinary Cupola Irons in the Electric Furnace

It has been claimed of superheating that it refines the graphite, and at least three theories have been put forward explaining this. Piwowarsky[1] states that the degree of superheating temperatures attained by the molten metal determines the percentage and fineness of the graphite in it. Osann,[2] on the other hand, seems rather inclined to think that refining is due to the following mechanism. As the iron remains a long time liquid in the electric furnace, "kish" or hyper-eutectic graphite has the opportunity to get out of the alloy, graphitisation then taking place at the true stable eutectic temperature, when cooling down in the mould, resulting in fine graphite. Hannemann[3] evolved the nuclei theory by saying that if one remelts pig-iron this does not result in all the graphite germs or nuclei being dissolved. Nuclei remain behind in the liquid iron and form the starting point for crystallisation of the graphite in the solidified state, which crystallisation is based on the dissociation of the cementite. When the iron is superheated, the nuclei are dissolved and crystallisation of the graphite results in a fine-grained form. In view of these theories and claims for superheated iron, several heats were tried transferring cupola-melted metal to the electric furnace and superheating to 1,600 deg. C. or over, without further addition; test-bars were taken before

TABLE I.—*Effect of Superheating Cupola-Melted Iron in an Electric Furnace.*

Heat No.	6		47		48	
	Cupola melted.	Super heated.	Cupola melted.	Super heated.	Cupola melted.	Super heated.
T.C per cent.	3.65	3.53	3.46	3.36	3.48	3.34
Si " "	1.89	1.92	1.23	1.16	1.85	1.67
P " "	0.25 max.	0.25 max.	0.25 max.	0.25 max.	0.25 max.	0.25 max.
S " "	0.1 "	0.1 "	0.1 "	0.1 "	0.1 "	0.1 "
Tensile, tons per sq. in.	9.0	12.4	15.1	16.2	12.9	14.8

* Paper read before the Scottish Branch of the Institute of British Foundrymen, Mr. E. J. Ross presiding.

1 Piwowarsky: "Progress in Production of High-Test Iron," Trans. American Foundrymen's Association, Vol. 34, 1926.

2 Osann: "The Manufacture of High-Quality Cast Iron," FOUNDRY TRADE JOURNAL, December 20, 1928.

3 Hannemann: "Stahl und Eisen," 1927, Vol. 47, p. 693.

and after this treatment, and Table I shows the results obtained.

On studying these results, one is forced to conclude that there is definitely an improvement, especially in the tensile strength, which is increased from 7 to 38 per cent., the greatest improvement being shown on the highest carbon content iron. However, one is forced to conclude that this improvement is due possibly more to the effect on the analyses than any effect

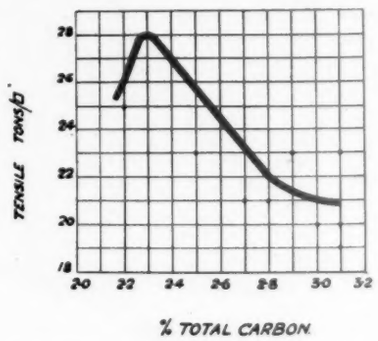


FIG. 8.—SYNTHETIC UNALLOYED IRON—EFFECT OF TOTAL CARBON ON TENSILE STRENGTH.

on graphite. As will be observed in all three cases, the total carbon has been increased by 3 to 4 per cent. of the original content, which might justify Osann's theory, but the silicon in two of the heats has also dropped about 10 per cent., suggesting oxidation.

The graphite structures were examined and Fig. 2, which shows the cupola-melted iron from

TABLE II.—*Synthetic Ordinary Irons.*

Heat No.	33	34
T.C per cent.	3.67	3.44
Si " "	1.72	1.34
P " "	0.1 max.	0.1 max.
S " "	0.1 "	0.1 "
Tensile, tons per sq. in.	10	17.3

heat No. 47 at a magnification of 100, reveals a large quantity of evenly-distributed, medium-sized graphite flakes. Fig. 3 shows this same heat after superheating in the electric furnace.

The graphite structure shows no improvement; if anything the flakes appear slightly larger than in Fig. 2.

Fig. 4 shows the higher silicon content iron as received from the cupola (Heat No. 48) and here the graphite structure is very little different from Fig. 2, the flakes being, if any-

TABLE III.—*Comparison of Cupola-Melted Iron with Synthetic Iron.*

Heat No. ..	Synthetic. 33	Cupola melted. 6	Synthetic. 34	Cupola melted. 47
T.C per cent. ..	3.67	3.65	3.44	3.46
Si " " ..	1.72	1.89	1.34	1.23
P " " ..	0.1 max.	0.25 max.	0.1 max.	0.25 max.
S " " ..	0.1 max.	0.1 max.	0.1 max.	0.1 max.
Tensile, tons per sq. in. ..	10.0	9.0	17.3	15.1

thing, larger. Fig. 5 shows the same iron as Fig. 4 after superheating in the electric furnace, and like Fig. 3 this shows no improvement; if anything the flakes are coarser, but more evenly dispersed.

From the examination of these structures one is forced to conclude that, under the circumstances described, superheating has failed to refine the graphite. Concerning Hannemann's nuclei theory it was decided to run two heats by melting steel, carburising this, and then adding the necessary silicon and manganese, so that the analyses would be almost similar to heats Nos. 47 and 48. By so doing, it was argued that there would be no existing nuclei to form the starting for crystallisation of the graphite, and a fine graphite structure should therefore result. Table II shows the results obtained.

A comparison between these irons and the superheated cupola-melted irons is shown in Table III.

It will be agreed that there is a very slight improvement with the synthetic irons over the

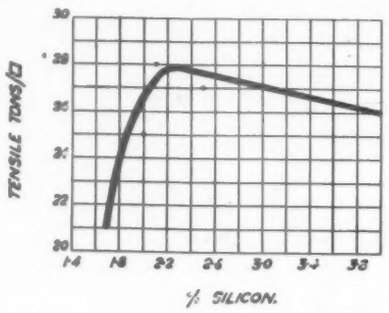


FIG. 9.—SYNTHETIC UNALLOYED IRON—EFFECT OF SILICON ON TENSILE STRENGTH IN THE RANGE 2.2 TO 2.4 PER CENT. T.C.

direct cupola-melted irons, and Fig. 6 shows the graphite structure of heat No. 33 which, if anything, is even coarser than the superheated cupola-melted iron of same analysis, *i.e.*, heat No. 48 (Fig. 5). Fig. 7 shows the graphite structure of heat No. 34, which, compared with the superheated cupola-melted iron of same analysis, *i.e.*, heat No. 47 (Fig. 3), appears even coarser structure.

Low Total-Carbon Irons

Although the foregoing experiments have shown slight improvement in physical tests over the ordinary cupola-melted irons, the results obtained are not, by any means, what is was

TABLE IV.—*Absorption Test. The Effect of Melting an All-Steel Charge with Varying Carbonaceous Materials.*

Heat No.	Carbonaceous material.	Metal charge.	Total carbon absorbed.	Carbon absorbed.
		Per cent.	Per cent.	Per cent.
34	Finely-ground coke	90 steel	2.46	49
35	Wood charcoal	0.5 Fe Mn	2.91	58
36	Ground electrodes	4.3 Fe Si	4.13	82
37	Plumbago	47 per cent	2.42	48
38	Blacking	5.0 carbonaceous material	3.08	61

originally set out to attain. The next line of attack left open, therefore, in the production of high-duty cast iron is, of course, the low total-carbon series. By this method, a smaller quantity of graphite should result, both by virtue of the lower total carbon and of the increased combined carbon and it is said that with the smaller quantity of graphite the individual flakes are smaller. The method employed to produce this low total-carbon iron was by using all steel charges, carburising to the desired amount and then adding the necessary silicon and manganese. Experiments were first of all made to decide which of all the carbonaceous materials commonly used in the foundry would give the greatest absorption of carbon. The procedure adopted in all cases was to charge the carbonaceous material on the bottom of the furnace, then steel, and after melting and superheating, silicon and manganese additions were made.

Table IV shows the results obtained. Heat No. 36 with ground electrodes gave the greatest absorption. It was therefore decided to use this form of material for carburisation of all steel charges throughout the remainder of the experiments since there was available a reasonable supply of used electrodes. Subsequent results, using this material, gave absorption figures as high as 98 per cent. The average, however, was in the region of 90 per cent.

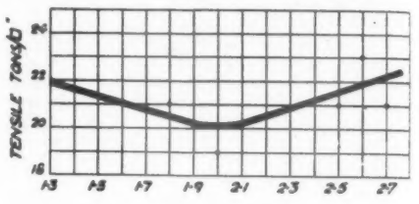


FIG. 12.—SYNTHETIC UNALLOYED IRON—EFFECT OF SILICON IN THE RANGE 2.7 TO 2.9 PER CENT. T.C.

Synthetic Unalloyed Irons

Following the procedure as described for the absorption tests, several heats were made with varying silicon and total-carbon contents in an endeavour to decide approximately the effect of these variations on tensile strength. Since the charge consists mainly of steel, with phosphorus and sulphur content in the region of 0.05 per cent., it has been taken for granted throughout the remainder of these tests that the effect of these elements remains constant; similarly

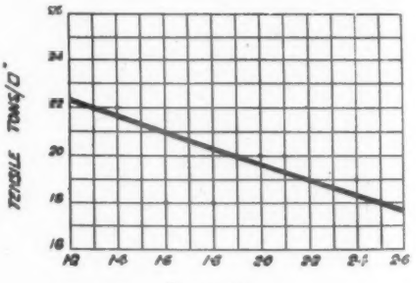


FIG. 13.—SYNTHETIC UNALLOYED IRON—EFFECT OF SILICON IN THE RANGE 3.0 TO 3.1 PER CENT. T.C.

with manganese, since additions were made to all charges to maintain this element at approximately 1 per cent. Table V shows the results obtained.

It will be seen from Table V that the total carbon varies from 1.7 to 3.1 per cent. and silicon from 1.2 to 3.9 per cent. In this series of tests the highest tensile strength obtained was 28 tons per sq. in., whilst the lowest was 18 tons per sq. in. Analysing these figures, the first point of interest is the effect of total carbon on tensile strength, and Fig. 8 illustrates this clearly.

The maximum point obtained, 28 tons, is in the range of 2.2 to 2.4 per cent. total carbon.

TABLE V.—*Synthetic Unalloyed Iron.*

Heat No. ..	43	3	19	27	28	29	30	31	32	34	35	37	38	73	74	75	76	77	78
T.C per cent. ..	3.1	2.8	2.7	2.3	2.8	2.2	1.7	2.2	2.3	2.5	2.9	2.4	3.1	3.1	2.7	3.1	3.0	3.0	3.1
Si " " ..	1.2	1.8	2.7	1.7	1.3	3.9	2.0	2.0	2.1	2.1	2.6	2.5	2.1	2.5	2.5	1.6	1.8	2.0	2.4
Tensile, tons per sq. in. ..	23	21	21	21	22	26	24	25	28	23	23	27	20	18	21	18	18	20	19

High-Duty Iron

Figs. 2, 3, 4, 5, 6, 7, 10, 11 and 14

Fig. 2.—Heat 47, Cupola Melted. × 100.

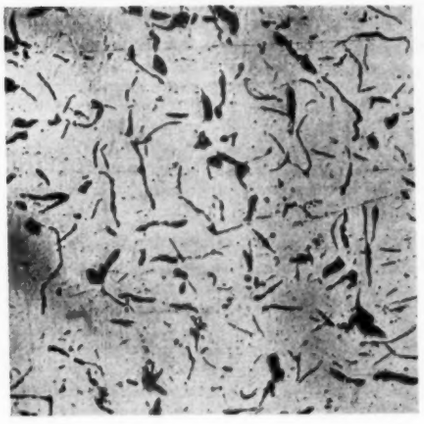


Fig. 3.—Heat 47 after Superheating. × 100.

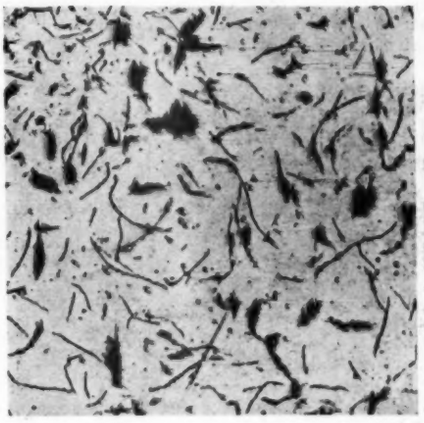


Fig. 4.—Heat 48. × 100.

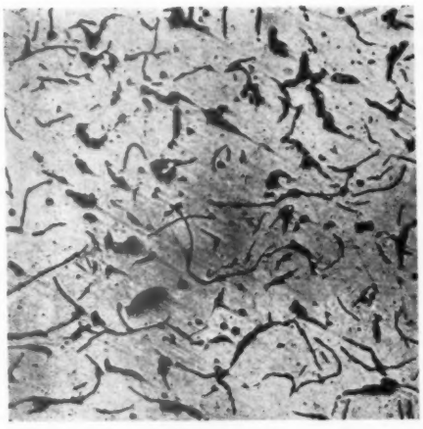


Fig. 5.—Heat 48 after Superheating. × 100.

Fig. 6.—Heat 33. × 100.

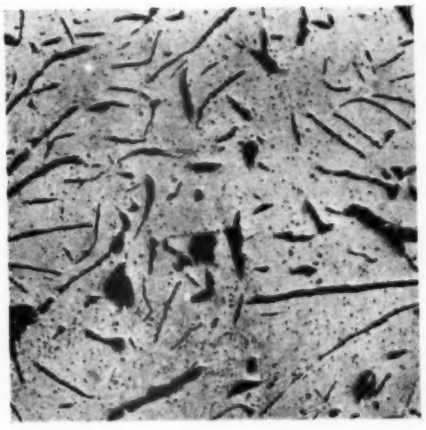


Fig. 7.—Heat 34. × 100.

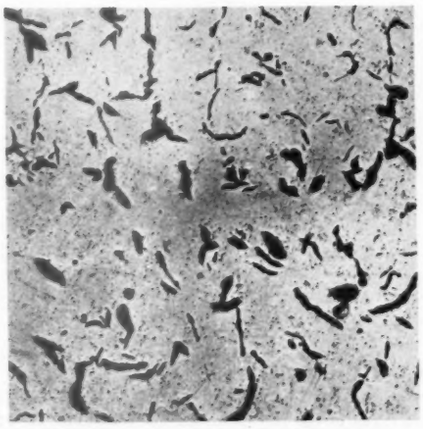


Fig. 10.—Heat 32. × 100.

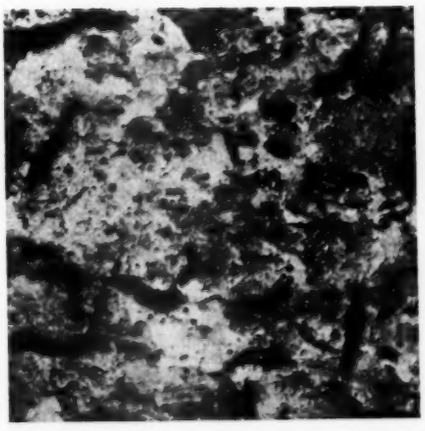


Fig. 11.—Heat 32. Etched. × 200.

Fig. 14.—Heat 8. × 100.

The lower tensile strengths follow with higher total carbon until, at 3.1 per cent. total carbon, an average of 21 tons tensile is apparent. Increasing the total carbon beyond 3.1 per cent. causes the tensile strength to fall in direct proportion until, at 4.0 per cent. total carbon, only 9 tons per sq. in. is obtained. This shows that with synthetic irons and electric-furnace melting there is no improvement over cupola melting other than that which can be obtained by adjustment of the composition.

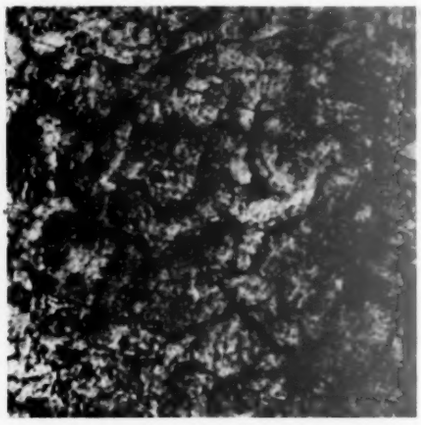


FIG. 15.—HEAT 8. ETCHED 1 PER CENT. HNO_3. × 200.

To study the effect of silicon in this range, it is necessary to sub-divide this group into three series of varying total carbon ranges, (I) 2.2 to 2.4 per cent., (II) 2.7 to 2.9 per cent. and (III) 3.0 to 3.1 per cent. total carbon. Unfortunately, the experiments have not advanced sufficiently to include sufficient evidence of the effect of silicon on the total-carbon range 2.4 to 2.7 per cent. It is intended to complete this range at a later date.

Dealing with total-carbon range (I), 2.2 to 2.4 per cent., *i.e.*, the range of highest tensile strength, Fig. 9 illustrates the effect of silicon.

It would seem that with increase of silicon from 1.6 to 2.0 per cent. the tensile strength is increased from 21 to 28 tons. Further increase in silicon appears to have very little effect on tensile strength, as at 3.9 per cent. silicon the

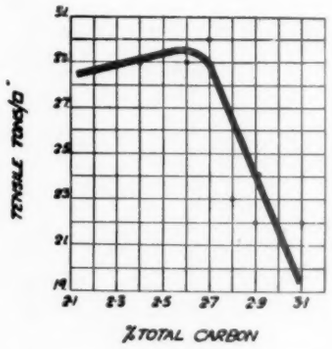


FIG. 17.—SYNTHETIC NICKEL IRON —EFFECT OF TOTAL CARBON.

tensile strength has dropped only two tons from the maximum, *i.e.*, to 26 tons tensile.

Fig. 10 illustrates the structure of Heat No. 32, the highest tensile, which shows a small quantity of evenly-distributed and finely-divided graphite. The magnification is × 100. Fig. 11 shows the etched structure (1 per cent. HNO_3 in alcohol) at a magnification of 200. The very fine pearlite grain size is worthy of note. This was not, however, clearly resolved until submitted to a magnification of 1,300.

In the next range (II), total carbon 2.7 to 2.9 per cent., Fig. 12 shows a silicon variation of from 1.3 to 2.7 per cent. produces very little effect on tensile strength. With a 1.3 per cent. silicon, the tensile strength obtained was 22 tons, whilst at 2.5 per cent. silicon, the tensile strength obtained was in the region of 21 to 23 tons per sq. in.

In the final range (III), 3.0 to 3.1 total carbon, Fig. 13 shows that increasing the silicon from 1.2 to 2.5 per cent. causes a decrease in the tensile strength from 23 tons per sq. in. to 18 tons per sq. in. From these graphs it would appear, therefore, that with a total carbon of from 2.2 to 2.9 per cent., increasing the silicon beyond 2.0 per cent. has very little effect on tensile strength, while, in the range 3.0 to 3.1 per cent. total carbon, increasing silicon causes a reduction in tensile strength.

Synthetic Nickel Iron

Before proceeding to discuss the results obtained under this group, it should be understood that the term "high-duty iron" refers only to high-strength iron. For this reason, the nickel content will be in the range of what is known as the low nickel content group, *i.e.*, 0.5 to 2.00 per cent. It is therefore not intended to deal with the heat- and corrosion-resisting austenitic irons with a nickel content of from 12.0 to 20.0 per cent.

From what has been published about the effect of nickel on cast iron, the following summary for this group may be made:—

(*a*) Tendency toward graphitisation of free-carbide (if this normally would be present in the absence of nickel).

(*b*) A perceptible hardening of the matrix, due to pearlite lamination being made finer and approaching a sorbitic structure as nickel is increased.

The statement that nickel is at once a softener and a hardener is explained by Dr. Everest[4] and Dr. Hanson[5] as follows:—Nickel is apparently about half as effective as silicon in graphitisation of free (eutectic and eutectoid) cementite. The reaction in grey irons is peculiar, in that nickel and silicon apparently act cumulatively in graphitisation of free cementite; but below the eutectoid transformation, nickel under the cooling conditions prevailing in ordinary casting sections apparently does not readily graphitise the combined carbon (cementite) of pearlite, and conceivably may retard somewhat the graphitising action of silicon. Silicon alone, within a certain range, decomposed the pearlite as well as the massive carbide.

Finally, concerning the effect of phosphorus, both Dr. Everest and Dr. Hanson conclude that phosphorus tends to reduce the influence of nickel on cast iron. From these observations the effect of nickel in personal experiments is at once apparent. First, as previously explained, since the charge consists of all steel with the phosphorus content in the region of 0.05 per cent., the maximum influence of the nickel content used, as far as this element is concerned, is obtained, and secondly, the conditions of casting the test-bars become more stable since cooling influences are less effective with nickel content.

Table VI shows the results obtained.

TABLE VI.—*Synthetic Irons with Nickel.*

Heat No. ..	8	14	20	23	24	61	63	62	64	65	66
T.C per cent.	2.7	2.9	2.7	2.4	2.6	2.8	3.1	2.8	2.9	2.8	2.9
Si ,,	1.5	1.8	2.8	1.8	1.5	1.7	2.1	2.1	2.0	2.0	1.8
Ni ,,	1.3	1.4	1.0	1.6	1.5	1.5	1.6	1.5	1.5	1.5	1.6
Tensile, tons per sq. in.	30	24	22	29	29	20	22	20	24	23	22

The range of total carbon is from 2.4 to 3.1 per cent.; nickel 1.0 to 1.6 per cent., and tensile strength from 20 to 30 tons per sq. in. Heat No. 8 gave the highest tensile strength of 30 tons. Fig. 14 illustrates the graphite structure of Heat No. 8, which is evenly distributed and reasonably finely divided. The magnification is 100 diameters. Fig. 15 shows the structure obtained by etching in 1 per cent. HNO_3 in alcohol, the magnification being 200 diameters. Fig. 16 shows very fine pearlite with some sorbite which is more apparent at a magnification of 1,000. In this series the effect of total carbon on tensile strength is at once apparent in Fig. 17.

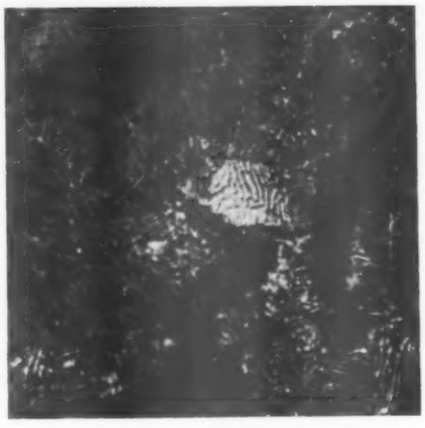


FIG. 16.—HEAT 8. ETCHED. × 1,000.

This agree with the graph, Fig. 8, for synthetic unalloyed iron, in that the highest tensile strengths are in the range of lowest total carbon, that is from 2.4 to 2.7 per cent. From what has been said regarding the influence of nickel, an interesting comparison has been obtained between heats of synthetic unalloyed irons of similar analyses and heats of synthetic nickel iron. These heats are set out in Table VII.

TABLE VII.—*Comparison of Similar Heats with and without Nickel.*

Heat No. ..	28	8	27	23	3	14	38	63	19	20
T.C per cent. ..	2.8	2.7	2.3	2.4	2.8	2.9	3.1	3.1	2.7	2.7
Si ,, ,, ..	1.3	1.5	1.7	1.8	1.8	1.8	2.1	2.1	2.7	2.8
Ni ,, ,, ..	–	1.3	–	1.6	–	1.4	–	1.6	–	1.0
Tensile, tons per sq. in. ..	22	30	21	29	21	24	20	22	21	22

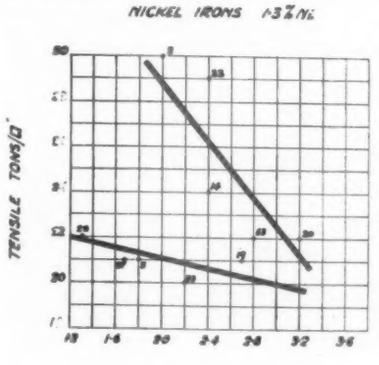


FIG. 18.—SYNTHETIC IRONS—COMPARISON OF SIMILAR HEATS WITH AND WITHOUT NICKEL (NICKEL IRONS CONTAINING 1.3 PER CENT. NI).

The effect of 1.0 to 1.6 per cent. nickel seems to be greater on the lower total carbon and lower silicon ranges, where the tensile strength has been improved by as much as 8 tons per sq. in. or about 30 per cent. Fig. 18 shows this effect clearly. The numbers on the graph indicate the heat numbers.

[4] "The Influence of Nickel Chromium on Cast Iron," FOUNDRY TRADE JOURNAL, January 3, 1929.

[5] "The Influence of Nickel on Iron-Carbon-Silicon Alloys containing Phosphorus," FOUNDRY TRADE JOURNAL, May 2, 1928.

Further experiments are still pending in this series, with varying nickel up to 2.5 per cent. on low total carbon 2.3 to 2.6 per cent. and low silicon from 1.3 to 1.8 per cent., when further illuminating results are anticipated.

Before leaving this series of tests it seems germane to describe an interesting experiment which was made in an endeavour to produce a grey iron by graphitising with nickel only. According to Pearce,[6] 4 per cent. nickel added to an iron with no silicon would produce supercooled graphite with resultant increased benefits.

FIG. 19.—HEAT 18 R. × 100.

Heat No. 18R was made to check the results with a 300-lb. melt. Table X shows the analyses and test results obtained from this heat.

Fig. 19 shows an area of the graphite structure obtained, which is supercooled. The mechanism of the production of this structure is said to be as follows:—"In ordinary flake graphite irons the inclusions are solid and crystalline." When the metal solidifies these inoculate the melt. In cases where supercooled graphite is deposited, it is suggested that the inclusions are still liquid externally when the metal solidifies so that these do not inoculate the melt, which subsequently supercools. Fig. 20 shows the etched structure,

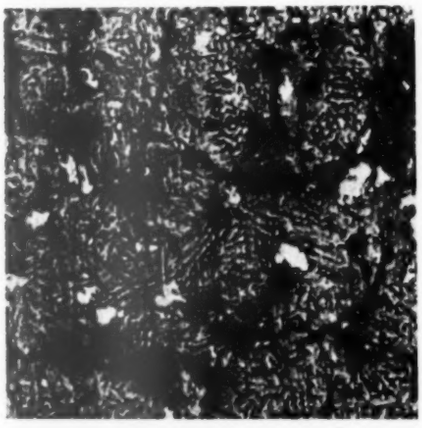


FIG. 20.—HEAT 18 R. ETCHED. × 200.

which has areas of pearlite free cementite and massive cementite. Either due to the presence of this latter structural constituent or to the presence of flake graphite as well as supercooled graphite or to the general combination, the test result on Table X is very poor, being only 17.2 tons per sq. in.

Synthetic Irons with Molybdenum

This series of tests originated in an endeavour to produce an iron which would give increased resistance to growth at temperatures about 315 deg. C. and little or no reduction in tensile strength at this temperature. From work published by Mussatti and Calbiani[7] there is some reason to believe that the carbide-stabilising tendencies of molybdenum may hinder growth after long periods at this temperature. The results of personal experiments in this field are not yet completed, but there are sufficient data to compare the effect of molybdenum on strength properties at atmospheric temperatures. Table VIII shows the results obtained in this series of experiments.

TABLE VIII.—*Synthetic Irons with Molybdenum.*

Heat No. ..	40	52	50	53	54	55
T.C per cent. ..	3.3	2.9	2.9	2.9	2.8	2.4
Si " " ..	2.3	2.2	2.4	2.4	2.6	2.0
Mo " " ..	0.46	0.48	0.5	0.47	0.48	0.47
Tensile, tons per sq. in.	17	22	20	22	24	28

It will be noted that the molybdenum content is maintained in the region of 0.5 per cent. When making these heats consideration was given to the high melting point of the 70 per cent. ferro-molybdenum used. This commences to melt at approximately 1,540 deg. C. and is not complete until a temperature of 2,100 deg. C. The procedure adopted in producing these heats was to melt the all-steel charge plus carbonaceous materials and superheat to about 1,600 deg. C.;

TABLE IX.—*Synthetic Irons with Nickel and Molybdenum.*

Heat No. ..	56	57	58	59
T.C per cent. ..	3.1	2.9	2.8	2.6
Si " " ..	1.7	2.0	2.1	1.0
Ni " " ..	2.0	2.0	2.0	1.8
Mo " " ..	0.47	0.48	0.45	0.32
Tensile, tons per sq. in. ..	25	24	31	33

then the ferro-molybdenum, silicon and manganese additions were made and the whole maintained at this superheat temperature for a period of at least 10 min. Studying the results obtained in the series, it will be noted that the tensile strength varies from 17 to 28 tons per sq. in. with total carbon varying from 3.1 to 2.4 per cent. Table XI gives an interesting comparison of synthetic unalloyed heats with heats of similar analyses from the synthetic molybdenum series.

TABLE X.—*Graphitisation with Nickel Only.*

Heat No. ..	18 R
	G.C 1.34 per cent.
T.C per cent. ..	2.84 C.C 1.5 " "
Si " " ..	0.51
Ni " " ..	4.17
Tensile, tons per sq. in. ..	17.2
Brinell	302

This comparison shows that there is very little effect or improvement on the tensile strength by the addition of approximately 0.5 per cent. molybdenum.

Synthetic Irons with Nickel and Molybdenum

This series was also introduced with a view to producing an iron which would give increased resistance to growth with little or no reduction in strength at temperatures ranging from 200 to 320 deg. C.

TABLE XI.—*A Comparison of Synthetic Molybdenum Iron with Synthetic Unalloyed Iron.*

Heat No. ..	53	35	54	74	55	32
T.C per cent. ..	2.9	2.9	2.8	2.7	2.4	2.3
Si " " ..	2.4	2.6	2.6	2.5	2.0	2.1
Mo " " ..	0.47	—	0.48	—	0.47	—
Tensile, tons per sq. in.	22	23	24	21	28	28

However, the physical results in the as-cast conditions, as shown in Table IX, are very interesting, inasmuch as tensile strengths as high as 31 and 33 tons per sq. in. have been obtained. Fig. 21 shows the graphite structure at 100 magnifications of heat No. 59, which gave the highest tensile, *i.e.*, 33 tons, and Fig. 22 the etched structure, at 200 diameters. It should be noted that very little graphite which is small is present. The etched structure shows practically all sorbite, which is more apparent at a magnification of 1,300.

There are not enough data to make a comparison with any of these heats, but from what has been observed personally of the effect of nickel and of molybdenum on synthetic ordinary irons, it would seem that the higher tensile strengths ranging in this series of experiments are more a function of the nickel content rather than the molybdenum content. However, further work has still to be carried out to confirm this.

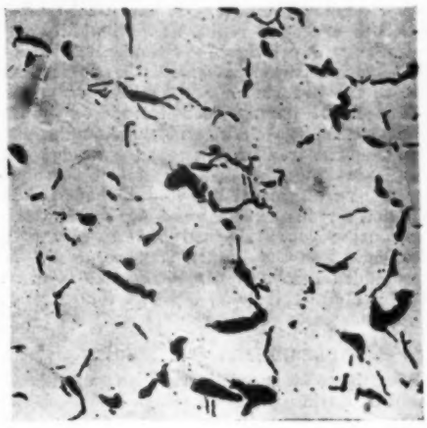


FIG. 21.—HEAT 59. × 100.

Conclusions

Summarising the conclusions arrived at in these experiments it would appear that:—

(1) Superheating is not the only factor, aside from composition, which materially affects the nature of the graphitisation.

(2) In synthetic low total-carbon unalloyed irons the tensile strength depends more on the total carbon. The highest range is in the region of 2.2 to 2.4 per cent. total carbon. Silicon beyond 2.0 per cent. appears to have little influence on tensile strength in the total-carbon range of from 2.2 to 2.9 per cent.

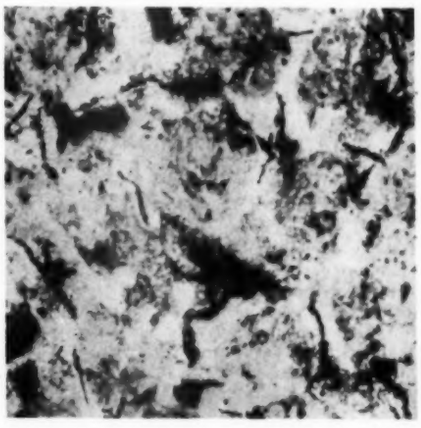


FIG. 22.—HEAT 59. ETCHED. × 200.

(3) In synthetic nickel iron 1 to 1.6 per cent. nickel induces an improvement in tensile strength, due possibly to the stabilisation of the cooling influences which prevail during casting (*i.e.*, retardation of graphite precipitation below eutectic temperature). The highest tensile range appears to be with total carbon from 2.4 to 2.7 per cent.

(*Concluded on page* 412.)

[6] "The Graphite Structure of Grey Cast Iron and its Modification," FOUNDRY TRADE JOURNAL, March 25, 1937.

[7] "Le Metallurgia Italiani," June, 1930.

Institute of British Foundrymen

SCOTTISH BRANCH-PRESIDENT'S ADDRESS

The Scottish Branch of the Institute of British Foundrymen held the first meeting of the new session in Glasgow, Mr. Daniel Sharpe (Past Branch-President) occupying the chair in the unavoidable absence of the retiring President, Mr. Frank Hudson.

A message from Mr. Hudson was read, in which he expressed regret at his inability to be present to induct the new President, Mr. E. J. Ross, and conveyed his best wishes to Mr. Ross and to the Branch.

MR. ROSS, having been introduced by Mr. Sharpe, took the chair, and thanked the members for the honour they had accorded him. They would not, he said, like to let the opportunity pass of according a vote of thanks to Mr. Hudson for his efforts on their behalf during previous session. He had been a very active President, and the Branch had prospered. Mr. Ross added that they would also like to convey to Mr. Hudson their best wishes for success in his new career.

PRESIDENTIAL ADDRESS

MR. ROSS then delivered his Presidential Address, during which he said:—

Mr. Sharpe and Gentlemen,—It is gratifying to know that, with a return of prosperity in trade, the membership of the Institute has increased considerably. During the less prosperous years in the engineering industries there was a reduction, but fortunately there was no diminution of the enthusiasm of those who carried on. It is to be hoped that the influx of new members will continue, and that there will be an increase of practical foundry workers who, in the coming years, will become executives.

The individual member is undoubtedly the mainstay of the Institute, and on his enthusiasm alone depends the life of the Institute. By regular attendance at the meetings his mind is broadened by having other men's points of view put before him. He is made to realise and appreciate various aspects of the industry, including those which may be beyond the sphere of his own activities.

The Papers read at the Conventions and Branch meetings all have within them the germs of possible improvements or suggestions illustrating the avoidance of pitfalls in design, layout, technique and practice. By a careful study and discussion of these Papers—no matter to which phase of foundry work they refer—one can extract points which are applicable to individual needs. One acquires an insight into methods of producing castings of different types, which may or may not be similar to those upon which one is normally engaged. A consideration of these methods will often reveal when and where such methods may be applied with advantage.

Design of Castings

In past years the problem of design has been extremely well discussed, and, where possible, this has been fully taken advantage of, particularly by those members who have been regular supporters and who have heard so much of the method of co-operation with the designing staff.

Another illuminating type of Paper is that which deals with the progress in lay-out of both fully and partly mechanised foundries. Many members must appreciate the general knowledge which has been disseminated by the excellent Papers on this subject. The results of this enlightenment are at the disposal of those responsible for the lay-out of future plants. The different types of production machines have been illustrated, with complementary conveying, sand-handling and cleaning plants, furnaces and necessary gear. A correlation of this knowledge is a definite asset in the contemplation of a new plant or alterations to existing plants.

From a consideration of the various technical and metallurgical Papers given, many members get their only insight into the scientific side of foundry work. By regular attendance at the meetings, members become familiar with the nomenclature, formulæ and practice, and obtain at least a rudimentary knowledge of the work that goes on, apart from that on the foundry floor. To illustrate this it is only necessary to mention one familiar subject—cupola practice, which has been thoroughly expounded as regards the theory of combustion, the reactions created and the results obtained.

On the metallurgical side, the Institute is responsible for imparting much knowledge to those in the industry who are denied the co-operation of a laboratory and its personnel. The tabulation of the results of analysis and physical tests with and without heat-treatment is a sphere in which the Institute is an outstanding medium, and by this means the practical man is informed as to the progress in the materials used in the production of castings.

New Data Made Available

Moulding sands and refractory materials have been graded, tested and tabulated in such a manner by laboratory staffs that the practical man has benefited considerably, and has now advanced beyond the older method of estimating the properties by touch or trial. This benefit may not be so apparent in jobbing foundries, but is certainly of great advantage in the present-day repetition or semi-repetition foundries.

Through the Institute, the patternmaker may learn of the pitfalls into which he may lead the moulder, particularly when specific jobs are illustrated to show what methods are necessary to overcome moulding difficulties, many of which are created through the lack of knowledge of foundry conditions. By the patternmaker and foundryman exchanging views on the methods to be adopted, fundamental principles are often originated and made applicable to certain types of work, so that previous disadvantages or omissions can be rectified or provided for in future creations.

The costing side of foundry work has been elucidated in outstanding papers. This, again, is a sphere of the foundry industry in which the Institute is virtually the only means available for many of the more practical and technical members to obtain an insight into costing methods, and for clerical members to study alternative methods. An executive with a definite knowledge of how costs are arrived at can readily visualise and foretell the probable ultimate costs of the various processes in the production of the castings.

The Papers are studied with one end in view, viz., the production of castings to meet various needs, but it really goes much further than that. There is a latent thirst for learning in everybody, in some purely academical, in others as a means to an end. Be that as it may, our energies, whether mental or physical or a combination of both, are concentrated towards a creation in the concrete form of the dreams of the inventor and designer. Moreover, few Papers are read and discussed that do not elicit, in return, expressions of other people's views. It may be corroboration of technique or practice, which is encouragement, or it may be their condemnation, which is in many cases the life of progress and a spur to attain perfection.

There are some prominent firms associated with the industry to whom the Institute is very much indebted. On the other hand, there are many engineering firms, either owning foundries or buying castings from outside foundries, who do not appear to realise the benefits which they derive through the existence of the Institute. The work of the Institute permeates the production of the castings they use, by reason of the foundry executives and workmen who are members of the Institute assimilating and putting into practice the knowledge obtained at the meetings and through the Institute's publications.

The time is now ripe for a determined effort to bring all the foundries and engineering firms not attached to the Institute into its membership. This could be done by bringing to their notice the advantages that they directly and indirectly receive through the work of the Institute. Only by some such extension of membership can the Institute take its rightful place amongst the great technical societies in the country.

MR. A. LAWRIE (Past Branch-President) proposed a vote of thanks to Mr. Ross for his address.

MR. H. WINTERTON (Past-President of the Institute), seconding, said it was a rule that Presidential Addresses should not be discussed, but he wished to refer to the wonderful way the Branch-President had solved the problem of what to say in a Presidential Address. The General Council of the Institute had been considering means of gathering together all associations in engineering to secure greater collaboration than in the past, and it was possible that, before the year was out, they might have made great progress in that direction.

MR. B. MACDOUGALL then presented his Paper on "High-Duty Iron—Some Experiments with the Rocking Arc Furnace" (see page 407).

High-Duty Iron

(*Concluded from page* 411.)

(4) Half of 1 per cent. of molybdenum in the lower total-carbon ranges, from experiments made, appears to have little effect on the tensile strength.

(5) In the nickel-molybdenum series a decided improvement was obtained, but whether this is a function of the 2 per cent. nickel added or the combination of nickel plus molybdenum, still remains to be proved.

(6) Finally, it would appear that the correct line of development for the production of strong irons is by lowering the total carbon, which results in a smaller quantity of graphite, whose individual flakes are smaller in a ground mass of very fine pearlite or, if possible, with sorbite, rather than endeavouring to produce refined graphite structures, as all the known methods of doing so are very uncertain in their results.

As has been stated at the beginning of this Paper, there are still several gaps to be filled in this series of experiments, the outstanding being the nickel-chrome series and nickel-chrome-molybdenum series. The author hopes at an early date, however, to be able to complete all of these.

In conclusion, the author wishes to express his appreciation of the very helpful co-operation of Mr. N. McManus and Mr. J. Arnott in connection with the preparation of this Paper; also to Mr. F. Hovell and Mr. Biles for their assistance in the production of the lantern slides; and finally to the directors of G. & J. Weir, Limited, for permission to publish this Paper.

Scrap Shipments to Japan

Japan has been out of the American scrap market for some months, and scrap exports to that country have declined since May, the peak 1937 month, with 443,251 gross tons, to 70,437 tons in September. The total of 1,806,943 tons of scrap exported to Japan in January to September, 1937, was 54 per cent. of the total of 3,335,194 tons exported during that period.

Die-Casting

SOME FUNDAMENTAL CONSIDERATIONS

A Paper on "Die-Casting" was delivered by DR. ARTHUR STREET to members of the Midland Metallurgical Societies at the meeting held on November 4. In the course of his lecture Dr. Street said that die-casting was a process which especially lent itself to the production of bulk quantities of metal fittings. Usually parts which were produced by die-casting were required in numbers of anything between 200 and two millions per annum. The weight of die-cast components generally ranged between half an ounce and twenty pounds, although, of course, both lighter and heavier die-castings were made. The process was mainly applied to the non-ferrous metals of low or medium melting-point, and he would say that 90 per cent. of the die-casting production in this country was made up of zinc-base and aluminium-base alloys.

Die-casting, continued Dr. Street, had three striking features which made it attractive from an economic point of view. A die-casting was cheap; it could be manufactured at high speed of output and, lastly, particularly in the pressure die-casting process, one obtained an accurate product which was a close approach to the finished job. Dealing with the two chief methods of production, the gravity and the pressure processes, the lecturer observed that, in gravity die-casting, the operations of the ordinary foundry were followed quite closely. The mould was opened and closed by hand, cores were inserted and extracted by hand, and the metal was hand poured. The only real difference between the making of a gravity die-casting and a foundry casting was that the cores and the mould itself were permanent and made of steel or cast iron.

Pressure Die-Casting

The pressure process aimed at being automatic in its operation and, so far as possible, the human element was reduced to a minimum. The mould was mounted on slides, one half being fixed and the other half movable, and in modern machines this die was opened by a hydraulic plunger and held together during the casting operation by the same means. Cores were inserted and withdrawn mechanically, and, when the finished die-casting was made, it was ejected from the mould by automatically-operated ejector-mechanism. The fundamental difference however, between the gravity and the pressure processes was that, in pressure die-casting, the metal in a liquid or pasty condition was squirted into the die under a very high pressure.

Some Points of Difference

There were very wide differences between the operation and products of the two processes, but in this country, because both gravity and pressure production was grouped under the general heading of "die-castings," people often failed to realise how definite was the boundary between gravity and pressure die-casting. Because the pressure casting was produced under extremely high working-pressure, its accuracy would be superior to that of the gravity process. It was found that, whereas the gravity die-casting would be accurate to about 0.005 in. per in., the pressure product would be accurate to between 0.001 and 0.002 in. per in. For the same reason, the finish of the pressure casting would be brighter and sharper than the gravity die-casting, although, of course, even a gravity casting would have a better surface appearance than the ordinary foundry casting.

It was usually easier to cast small holes in the pressure die-casting and to produce articles of thinner sections. For instance, one could die-cast a zinc-base alloy pressure casting with a section of $\frac{1}{32}$ in., but to make a successful gravity casting, the wall thickness would probably have to be twice as much. On the other hand, one could frequently obtain more complexity with the gravity die. Thus, automobile pistons were usually made by gravity die-casting, because this process allowed the manipulation of built-up cores to make the undercut portion.

Production Datum Base

A gravity die, said the lecturer, was quite a simple affair; it did not have to be made with the extreme accuracy of the pressure mould, and because it was not subject to the erosive effect of metal under pressure, the gravity die could often be cheaply made of cast iron or mild steel. The setting-up time of the gravity die was small compared with that for the pressure mould, and because of that, coupled with the less expense of the gravity mould, the process could be applied with economic success for numbers of the order of 500 to 1,000 die-castings per annum. The pressure die must be a piece of precision mechanism. In most cases it had to be sunk in an alloy steel, which was subsequently heat-treated. The die had to be provided with core-operating mechanism, ejector mechanism and water cooling. Further, it had to be set up with great care on a die-casting machine, the initial cost, running expenses and overhead charges of which were considerable. It was not, therefore, usually economical to apply pressure die-casting to small production, and it should be generally reckoned that pressure die-casting became of value when the quantities required exceeded 5,000 per annum.

The making of a pressure die-casting could be compared with putting a sponge into the die and then wringing the sponge out. The metal entered the die in the form of a turbulent spray, and this metal was bound to be accompanied by the air which was previously contained in the mould and crucible; consequently the venting of a pressure die had to be skilfully arranged. In many cases, the joint at the two halves of the die was sufficient to allow the escape of the entrapped air, but for complex jobs, special venting grooves were necessary. The skilful venting of a pressure die was one of the most important points in the production of a satisfactory die-casting. In recent years, it had been realised that there was another important factor to be considered in the manufacture of a pressure die-casting, namely, the working pressure. Obviously, if the condition of the metal when it entered the die was compared with a sponge, then to wring out the sponge completely necessitated a very hard squeeze, and in practice it was found that the application of high working pressure meant that a more solid product was obtained. This high pressure, however, must not be used in an uncontrolled way, because if a die were unscientifically vented, badly made and run in the wrong position, the effect of the high pressure would be to magnify the effects of these faults.

Manufacturing Difficulties and Considerations

Most pressure die-castings had a pleasing and sharp surface appearance, but there were, even to-day, far too many the insides of which showed that the sponges had not been completely wrung out. Possibly those who were engaged in the die-casting industry should make themselves more conscious and critical of the internal condition of the die-castings which they produced. In certain cases, however, the design of a part was such that solidity was almost impossible to attain.

In choosing an alloy suitable for die-casting, Dr. Street pointed out that there were three main factors which had to be considered:—(1) The raw material cost, (2) the physical properties of the alloy rendering it suitable for the particular job, and (3) the suitability of the alloy for production by die-casting. Raw material cost must be considered, but it was not of paramount importance. Because of the solidity and fine grain of a die-casting, its strength was usually higher than a corresponding foundry casting. Further, in most cases, subsequent machining operations were unnecessary, so that quite often, when a part was die-cast, its ruling section was deliberately reduced and the amount of raw material in it thus became lessened. The main problem was the selection of an alloy which would die-cast well and which would have properties that were worthy of the general finish of the die-casting. As an example, the lecturer mentioned that, among the aluminium alloys, it was found that the one which pressure die-cast best was that containing about 12 per cent. of silicon. This alloy happened to be one of the most expensive of the casting alloys, but because it could be pressure die-cast so satisfactorily, and because at the same time its strength, corrosion resistance and other properties were very good, the fact that its raw material cost was high was not allowed to interfere with its extensive use in the die-casting industry. As regards the physical properties, there were numerous questions which had to be considered: Would the alloy be strong enough; had the part to withstand shock or alternating stress; did the part work in any specially corroding conditions; did it have to be soldered; or must a special finish be applied to the die-casting?

Physical and Metallurgical Desiderata

Both the user and the die-caster should consider whether the alloy would be suitable for production by die-casting. The thermal effect had to be considered, also the erosive effect and the solution effects of the liquid metal on the die steel. The alloy must be fluid at a temperature near its melting point, and it must not be hot short, otherwise it would crack under the constraint of the die. The alloy must solidify in just the right way, otherwise air might become entrapped in the die-casting. Certain alloys—for instance, aluminium bronze—were more suited to the gravity process, and others, such as aluminium and zinc-base alloys, were essentially pressure die-casting alloys. The alloy which was used must not have any chemical or solution effect on the steel of the die. It was possible to die-cast pure zinc providing that zinc of extreme purity was used, and providing also that the part to be die-cast was not very elaborate. But pure zinc dissolved in iron, so that the production of such a casting would mean that in quite a short time the mould would become galvanised. There were two means which might be adopted to prevent this, namely, a steel die could be used, alloyed in such a way that the zinc would not dissolve it, and a much simpler means by alloying the zinc with an element which rendered it incapable of attacking the iron. Such an element was aluminium, and with about 4 per cent. of this metal there was practically no danger of iron being attacked by the die-cast metal.

The freezing characteristics of the alloy were an important factor in the consideration of the die-casting properties of an alloy. The alloy in the liquid or plastic condition was ladled into a metal container, and some method was adopted of injecting this metal at high velocity into the mould. As it entered the die, the metal was in a dispersed and turbulent condition, but with the continued application of pressure, all the air was forced out through the vents and the solidifying metal was forged into a solid casting. The cooling was extremely rapid, because in most cases the die was water-cooled. Three things were therefore of extreme importance:—(1) The alloy must be reasonably fluid at a temperature

in the neighbourhood of its liquidus; (2) it must not be hot-short at a temperature directly below its freezing point; and (3) an alloy which was to be pressure die-cast satisfactorily must have a short, though very definite, plastic range directly after freezing, so that it remained pliable while all the holes were being squeezed out of it.

Steel-Mould Specification and Life

Particularly in pressure die-casting, the steel mould was affected by several influences, which might be divided into four groups, namely, thermal effect, erosive effect, solvent effect, and surface tension effect. It was the joint result of these four factors which had to be considered in discussing the effect of a die-cast metal on the mould, although the thermal effect was of outstanding importance. No hard and fast rules could be given for telling the anticipated life of a mould: the die life would vary enormously with the size and complexity of the job; thus in some cases a mould producing zinc-base die-castings would give trouble after only 50,000 operations, while other dies for the same alloy would satisfactorily produce as many as two or three million components. For certain purposes a brass pressure die-casting might have a die life of four to five thousands operations, while with other die-castings in the same alloy as many as 20,000 or 30,000 shots would be achieved.

If zinc alloy, aluminium alloy and 60:40 brass all melted at the same temperature of 400 deg. C., the zinc would be easiest to die-cast; brass would be a good second, and aluminium would be relegated to third place. Aluminium alloys had the double disadvantage of high shrinkage together with a tendency to cling to the steel parts of the die. Consequently, in die-casting aluminium alloys, not only did the cores have to be tapered nearly ten times as much as for zinc-alloy, but there was a continued likelihood of the metal sticking to the cores, so that the mould became scored when next the core was inserted into position. If only brass did melt at 400 deg. C., then brass pressure die-casting would present few problems. As it was, 60:40 brass melted in the region of 870 deg. C., and although the temperature of the die-cast brass was arranged to be so low that the metal was pasty and not liquid, yet the thermal effect of the injected metal was so severe that the maintenance of such a die was a continual problem. A chrome-vanadium steel was inadequate for brass pressure die-casting, and a tungsten steel had to be used to withstand the heat. The use of that steel, however, introduced a peculiar problem, because its thermal conductivity was so low that the heat could not be transmitted away fast enough. Generally it paid to design a brass pressure die-casting so that the section was even all over, between $\frac{1}{16}$ in. and $\frac{1}{8}$ in. thick.

Practically any shape could be die-cast, but it was important to remember that there were certain complexities of design which would make the die-casting expensive, because they tended to retard production and because they increased the likelihood of die breakdown. There were several reasons why designers were tending to co-operate with their die-casters in the early stages of planning for a new job. If a new part were designed specially for die-casting, it was usually found that it was cheap to produce; it reduced to a minimum the wear on the die, and also the job specially designed for die-casting generally proved to be mechanically superior to a part which had been designed without reference to the needs of the process. Concluding, Dr. Street reminded his listeners of a number of well-known principles. The section of a die-casting should be arranged to be uniform, and most certainly there should never be any abrupt changes from a heavy section to a thin wall. Sharp corners should be avoided wherever possible, as they introduced planes of weakness, and large areas or flat surfaces should be broken up by ribbing where possible. Cored holes should, when convenient, be arranged so that they were assembled in as few planes as possible.

Alloys of Iron Research Monographs

A NEW VOLUME REVIEWED BY DR. W. H. HATFIELD, F.R.S.

"ALLOYS OF IRON AND CHROMIUM." Vol. 1. By A. B. Kinzel and Walter Crafts. Published by the McGraw Hill Publishing Company, Limited, Aldwych House, London, W.C.2. Price 36s. net.

This series of monographs, published under the auspices of the Iron Alloys Committee of the Engineering Foundation (U.S.A.), has already attained a very considerable reputation, the work under review being the 9th in a series which has now dealt with the metal iron, the alloys of iron with carbon, molybdenum, silicon, copper and tungsten respectively and with the principles of phase diagrams.

These monographs essentially consist of series of correlated abstracts of existent data, including not only published work but the results of many unpublished researches relating to the alloys under review, each chapter concluding with a clear and concise review of the data presented.

The present volume forms the first part of the monograph on "Alloys of Iron and Chromium," and relates to irons and steels containing less than 10 per cent. chromium. The second part, now in course of preparation, will deal with iron alloys containing more than 10 per cent. chromium, and thus steels of the corrosion and heat resistant type will come within the category covered by the forthcoming publication.

In the opening chapter the authors express the hope that the data here presented will give "a clear understanding of the present status of chromium steels and cast irons" and form a base at which the research worker will find "arrows indicating the general direction and probable character of the as yet unknown and unexpected domain immediately ahead." A study of the work reveals that this hope is fully justified.

The subject is dealt with clearly and logically, and after an introductory chapter on the history of chromium, the authors proceed to discuss the preparation and properties of chromium metal and ferro-chromium; the constitution of the iron-chromium and iron-chromium-carbon systems and the effect of chromium on the critical points. Three chapters are devoted to the general effect of chromium in iron and steel, and the manufacture, heat-treatment and properties of chromium steels. Attention is then given to the influence of additional alloying elements, referring to manganese, silicon, nickel, copper, molybdenum, vanadium and tungsten. The high-carbon and other chromium-containing tool steels are discussed, and the authors then pass on to the special purpose steels such as the nitriding, chromium-magnet, armour, and high-speed steels.

Low-chromium cast iron is dealt with from the point of view of production, structure and properties, whilst some consideration is given to the effect of chromium on the heat-resistance and high-temperature strength of such irons.

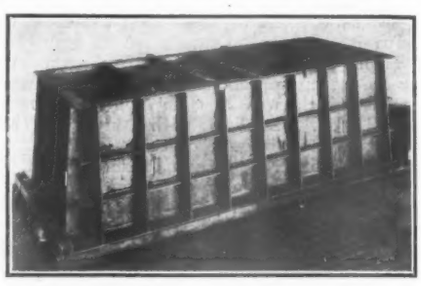
The concluding chapter relates to steels containing 4 to 10 per cent. chromium, thus leading up to the high chromium alloys which are to form the subject of the second volume. These medium chromium steels, although not usually regarded as corrosion resistant steels, are widely used for oil stills and similar applications. Useful data are included on the effect of alloying elements such as tungsten, molybdenum, titanium and tantalum, on these steels.

It is stated that, in the preliminary search, some nine thousand articles and technical Papers were assembled. Of these, 478 were selected for detailed study. The selected Papers have been arranged chronologically and form a very excellent bibliography of the subject. There is little doubt that readers will find in this bibliography a very useful feature of the book.

The volume includes a wealth of data in the form of tables and diagrams. These are excellently prepared and all references are clearly indicated.

A Hard Lead Alloy

A new hard lead alloy has been developed in France by Louis Groc, of Paris. It is composed of lead and antimony, which is supposed to obviate the disadvantages of lead while retaining its advantages. The alloy is claimed to have a rigidity equal to that of iron, which makes it possible to use it for all sorts of castings and pipes used for the chemical industries or for hot-water installations. The pipes and their fittings are made up in any diameter from



VAT MADE OF HARD LEAD-ANTIMONY ALLOY.

about 1.18 in. and the lengths are assembled by means of flanges, fastened by bronze bolts. The apparatus is made up exactly as if it were in cast iron, with reinforcing ribs for large pieces. If desired, the parts can be soldered together with an autogenous solder or can be bolted through suitable flanges, the joints being packed with rubber or asbestos. Our photograph shows a vat which is made of this hard lead alloy.

Catalogues Received

Branding Irons. Leaflet No. 66, issued by the Cressall Manufacturing Company, Limited, of Eclipse Works, 31 and 32, Tower Street, Birmingham, 17, deals, so far as we are concerned, with a novel application of electric heating. It describes an electrically-heated branding iron, and the face of the iron is so constructed that a trade mark, letters or figures can be slid into dovetail grooves. As a foundry tool it shows real possibilities in branding shovels, riddles, and loose tools, and for marking patterns on the unworked surfaces. Another obvious use is the trade marking of "brandable" goods.

Sawing and Grinding Machines. From the firm of F. H. Ockenfels, Slough, Bucks, we have received two leaflets numbered KS 81 and BS 71, the former dealing with a high-precision saw for metals and the latter with metal band-grinding machines. Four types of saws are dealt with, giving a speed range from 125 up to 500 r.p.m., and the slower-run machines carry up to six speeds. A maximum of adjustability has been incorporated. Many novel features are shown by the metal-belt grinding machine, the outstanding one being the angularity at which the belt can be fixed. Moreover, there is a dust catcher installed in the base of the machine. The neat appearance of this machine is commendable.

Continental Steelfoundry Practice

Following Mr. P. Fassotte's lecture on "Trends in Continental Steelfoundry Practice," given to the London Branch of the Institute of British Foundrymen and printed in our last issue, an interesting discussion arose as to the more outstanding differences between the practice of British and Continental steelfounders.

Origin of "Green" Sand

MR. V. C. FAULKNER (Past-President of the Institute) asked whether in Belgium steel castings were being used for jobs for which, in England, malleable would be used. He believed that for railway switch work, for instance, there was a difference of practice as between the two countries. Bearing in mind references made to North-East Coast hematite, he asked whether it was still the custom of the Franco-Belgian group of founders to import iron from England or whether they had a local substitute.

Discussing sands, he said he had been told by Dr. Werner, who had lectured to the Branch on a previous occasion, that near his works at Düsseldorf there was some green-coloured sand and that that was definitely the origin of the expression "green sand." He believed also that Dr. Werner was using that local green sand in his steelfoundry. There was also a green-coloured sand available in England.

Probably the finest metallurgical laboratory in Europe was the old steelfoundry at Le Creusot, where there was a range of open-hearth furnaces having capacities varying from 5 tons up to about 25 tons. That installation was supplemented by a converter plant, a crucible plant and the electric furnaces which he had had the privilege of installing there. He asked whether the crucible process was still being used on the Continent; he believed it was used very extensively in one of the very large works until quite recently.

A year or two ago, he continued, there had been very considerable discussions in Australia as to whether the product of the converter was good enough for their best type of acceptance specifications. Therefore, he wondered whether the converter steel was universally accepted throughout the Continent as being of the highest class.

Metallic Losses

With regard to metallic losses, he asked whether they were of the same order in France as in England; he was under the impression, he said, that they were distinctly higher on the Continent than here.

As to the manufacture of manganese steel, he believed the governing conditions on the Continent should be much the same as in England, *i.e.*, they would use the electric furnace if there were an abundance of manganese steel scrap available. Another question was whether any progress had been made on the Continent with the use of electric furnaces for the heat-treatment of steel castings, for the newest steel foundry in Great Britain had adopted that process.

Finally, he asked whether a machine known as the Speed muller had made its appearance on the Continent; it had already found its way from America into Australia. Using the principle of centrifugal force, the Speed muller had 2-ft. diameter rubber-covered balls running round at about 90 r.p.m., the centrifugal force forcing the balls against the muller pan, which was rather like a milk basin. The apparatus was stated to prepare sand very rapidly without crushing the grains, at something of the order of 10 cub. ft. per minute.

Steel or Malleable Applications

MR. FASSOTTE replied that he knew nothing of the Speed muller, and therefore, could not give a considered opinion with regard to it. Dealing with the question of steel castings *versus* malleable iron in Belgium, he said that malleable had not made the same strides in Belgium and France as in Germany or in this country. The reason probably was that the Belgian steelfoundries, having specialised largely on repetition work in green-sand moulds, had always been able to produce a casting which would compete economically with malleable. Automobile works in France, for instance, relied on steel castings to a far greater extent than in this country, in spite of the fact that the malleable foundries had developed the manufacture of blackheart malleable; they were producing in steel a large number of motor-car castings which in Great Britain and certainly in the United States would be made in malleable.

The Belgian steelfounder had a preference for English hematite. He had alternative sources of supply, however; it was available from several sources, including a Dutch blast furnace organisation, and occasionally a French hematite was used in Belgian foundries. The bulk of the supplies, however, still came from this country.

Mr. Fassotte said that he knew the green-coloured sand referred to by Mr. Faulkner as being produced at Düsseldorf; in Belgium also there were some green-coloured moulding sands, and one pipe foundry was using such a sand exclusively. Another type of sand, also green in colour, was used largely for the making of manganese steel castings, for it was practically devoid of oxide of iron.

There might be some crucible furnaces in use still in Belgium, but he knew of none either in Belgium or Northern France.

Mr. Fassotte said he felt it was beyond the scope of his Paper to give a personal opinion on the question as to whether the product of the converter was good enough to be used in castings to the highest specifications. It would be somewhat invidious, he added, to make a comparison between converter practice on the Continent and in Great Britain. Metallic losses in the converter varied from works to works on the Continent, just as in this country.

MR. FAULKNER suggested that they varied from 12 to 18 per cent., roughly.

MR. FASSOTTE replied that, in practice, the losses varied from 13 per cent. to almost anything. However, he was of the opinion that some of the best practices were found in this country. He was aware of only a single instance of the use of an electric resistance furnace for the heat-treatment of castings. The annealing furnaces usually used were fired by stoker grates, by pulverised fuel, or by oil.

He agreed that the availability of manganese steel scrap governed the choice of process, and added that the induction furnace was being used considerably nowadays for the production of manganese steel as well as the basic arc furnace.

Critical Sections for Green-Sand Practice

MR. J. DESCHAMPS asked what was the critical thickness up to which castings were made in green sand on the Continent, for he believed that in this country the attempts at green-sand moulding had been limited to relatively thin castings up to now. Commenting on Mr. Fassotte's rather casual reference to lip pouring, Mr. Deschamps asked why that method of pouring was more prevalent on the Continent than here. As to the extensive use of chamotte in Germany, he said he could never understand what took place during the calcination of chamotte; he understood that it was a kind of siliceous clay, that it was not a carbonate and was not supposed to lose any weight on being calcined; he wondered why it was calcined.

Refining in the Induction Furnace

Discussing the author's references to the refining of steel in high-frequency induction furnaces, and the very important matter of the effect of the slags during the refining, Mr. Deschamps had in mind the Perrin process, which was used extensively in the Ugine plant in France and was very promising. By the use of molten synthetic slags one was able to remove practically the whole of the phosphorus content of any given steel, and he mentioned its application to converter steel in practice, where the chief difficulty was due to the presence of phosphorus. It seemed to him that one could apply that process of intimate mixture of the steel with molten synthetic slags of a highly basic and oxidising nature in a ladle; it appeared to be more or less instantaneous, and should enable one to produce in a ladle the sort of reaction which Mr. Fassotte had mentioned as taking place in the crucible of the high-frequency furnace, where slags were used for refining.

Bogie Under-frames

Coming to the work of some of the French steelfoundries, particularly the production of bogie under-frames for sleeping cars, tenders and bogie carriages generally, representing the most intricate type of steel casting, Mr. Deschamps said he had seen a number of those frames made on the Continent and had been astounded by the quality and the efficiency. He had seen those big frames, about 8 ft. long, 5 ft. wide and 2 ft. deep, full of cores, and with thicknesses of $\frac{1}{4}$ in. or even less, in a single casting, coming out of the moulds without any cracks; they were not made in green sand, but in a special type of sand mixed with manganese dioxide. The process was quite new and was full of possibilities, and he believed it would come to this country in due course. Discussing the theory of it, he said that if an ordinary oil-sand core were used, the linseed oil in it became oxidised and gave a substantial bond to the sand, but enabling it to collapse under contraction stresses when the oil burned away. In the case of a fairly thick core, there was oxidation only at the skin; one could not expect the oxygen of the atmosphere to have more than a superficial action. On the other hand, if there were mixed intimately with the sand and linseed oil a certain amount of manganese dioxide, which latter, when the sand was hot, yielded very easily one atom of oxygen, the linseed oil in the very heart of the core became oxidised. Thus, there was the possibility of using less linseed oil and of increasing the collapsibility of the sand under contraction stresses.

Riser Removal

The developments in connection with the removal of the risers by means of disc saws were very interesting, but he wondered whether the greatest drawback was the very high cost of maintenance of the saws. In his experience the cost of upkeep of the saws seemed to be terrific, and he asked whether they had inverted teeth or whether they were solid saws.

As to the heat-treatment of steel castings in the electric furnace, he asked what tonnage of steel castings could be dealt with economically in that furnace; if the current could be supplied at sufficiently low cost, we should be able to avoid some of the problems of the oxidation and scaling of castings and of distortion through lack of uniform heating in the annealing oven.

It was not at all difficult to satisfy the Australian authorities that properly-made converter steel would meet their specifications. Some foundries in this country, operating only the converter process, were making steel castings which met very easily the requirements of all existing specifications for plain carbon steel castings.

Speed in Casting Green-Sand Moulds

MR. FASSOTTE said that when he had referred to the use of natural moulding sand in Germany he had mentioned that opinions varied considerably with regard to the limitations of that sand. The same was true also with regard to the limitations of green-sand moulding; every foundry had a different view from others concerning the extent to which green-sand mould-

ing could be carried on and the extent to which it was worth while carrying on with it. The rule generally followed by Belgian foundries was not to worry so much about the weight or wall thicknesses of castings, but to cast a green-sand mould on the same day as that on which the mould was made; very rarely was a green-sand mould left over night. That fact would indicate probably more definitely than anything else the general opinion about the limitations of green sand. He had in mind a foundry which was producing large gear segments, weighing 5 cwt. each, in green-sand moulds, although the wall thicknesses must have been two or three inches; there was no hesitation about producing those castings in green sand, provided that they were cast on the day the moulds were made. Green sand was used essentially for repetition work—machine-moulded and small hand-moulded work.

Reasons for Lip Pouring

The reason why lip pouring was used to such a large extent in Continental steelfoundries was because of their adoption of their green-sand practice. Obviously the green-sand mould was not so strong as a dry mould, and must be dealt with carefully. Lip pouring was more gentle in its action and was, therefore, preferred in many foundries for casting green-sand moulds. Exactly the same consideration applied to shank pouring. The use of shanks entailed inevitably considerable loss of metal, and careful records tended to show that the losses could be as high as 5 per cent. of the total weight of metal; yet for a number of castings it was worth while to put up with that loss solely to enable advantage to be taken of the gentle action of shank pouring.

He could not give a full explanation as to why chamotte was calcined at a very high temperature, unless it be that the main reason was the same as that of the maker of firebricks, who calcined his material first in order to eliminate as far as possible the initial contraction.

Slag Reactivity

With regard to the reactivity of slags used in the basic induction furnace, Mr. Fassotte said he had mentioned particularly that the slags were kept very thin, obviously with a view to speeding up the reactions. He had been present quite recently at the end of an operation carried on in a large induction furnace where a de-phosphorising slag was used in the last instance; the period between the moment of generating the slag and the moment at which the slag was skimmed off was only 3 minutes, a fact which indicated a very rapid reaction. There was some measure of similarity between this refining in an induction furnace and the Perrin process to which Mr. Deschamps had alluded.

Manganese Dioxide in Cores

The use of manganese dioxide for making collapsible cores and moulds was not extensive, so far as he was aware; he would not be dogmatic as to the extent to which it was used, but he had heard of only one foundry which was using it. Many of the under-frames for bogies, mentioned by Mr. Deschamps, indeed the majority of them, were made in plain green-sand moulds. He had tried to ensure that his Paper would be as non-controversial as possible, and it was not for him to express an opinion on the matter, but it was a fact that most foundries preferred to make those under-frames in electric steel. He had no personal experience of the manganese-dioxide sand mixture, but he understood that it was necessary to take certain precautions with regard to the making of the core-boxes, and special precautions had also to be taken concerning the temperatures at which the material was rammed.

Disc Sawing Machines

All the disc saw machines which he had seen in operation recently were very rigidly built, in order to prevent vibration of the saw; the square section of the headstock measured about 12 in. per side. Even so, there was a certain amount of vibration in a particularly heavy job which he had seen. But the experience of the users of that machine was entirely favourable. He supposed that the main cause of breakage of the saws or of the teeth of the saws was lack of rigidity of the machine, and the construction of the modern tools was such that this main objection was actually overcome.

Replying to Mr. Deschamps' question concerning annealing in electric furnaces, he said that the main problem was that of price of fuel. It seemed to him doubtful that the electric furnace could meet the competition of other methods of firing unless a continuous furnace were used. High cost of fuel was a terrific handicap in the economic operation of any furnace used intermittently, whereas for continuous the higher priced fuels might be considered. It was a very open question whether it would ever be practicable to use a continuous furnace fired by a fuel so expensive as electricity in a steelfoundry, which had to anneal castings of widely different sections.

X-Ray Examination

MR. W. B. LAKE, J.P. (Vice-President of the Institute), asked to what extent the X-ray process of examination was used by those firms which had installed it. Did they use it merely on trial castings, or did some firms actually X-ray all the important castings they produced?

The reference in the Paper to the quenching of steel castings in order to obtain reduced grain size recalled to his mind a conversation he had had with Héroult many years ago, when investigating the electric furnace. Héroult had been the first man to tell Mr. Lake that if a steel casting were to be made as good as a forging, it must be quenched and that the carbon must be 0.3 per cent.

In asking for a little more explanation of the machine used for sawing-off the heads, etc., from castings, Mr. Lake said he had not quite gathered the principle on which they worked. Did the headstock itself carry the saw, or did the headstock carry a big chuck, and was the saw run on separate bearings?

Finally, Mr. Lake bore testimony to the great interest which Mr. Fassotte's Paper had created. He had made up his mind that he must be present when the Paper was presented, even if it meant driving home in the fog at night. He hoped he would not be regarded as impertinent in saying that he had never met any other visitor from the Continent who had been able to express himself so well as Mr. Fassotte had done in the English language.

MR. FASSOTTE said that, to his knowledge, only one type of steel casting was produced where each individual casting had to be subjected to X-ray examination, namely, certain castings produced for aircraft in a particular country. In foundries generally where X-ray apparatus was installed, it was not applied to every individual casting, if for no other reason that at present the process was so slow. The penetration of X-rays through steel was such that with an apparatus of 200 or 300 kilo-volts, one could get a direct reading for only a very small thickness; the exposure of photographic plates, as said, was slow.

MR. LAKE said that by X-rays one could examine steel to a depth of about 3 in.

MR. FASSOTTE agreed that that could be done by means of photographs, but not by direct reading. It was the practice to examine light alloys, such as those of aluminium, by X-rays visually, but that was not the case with steel castings, and the fact that the process was so slow was perhaps the greatest impediment to its development.

With regard to the machine used for sawing off the heads, etc., of castings, Mr. Fassotte remarked jocularly that the fact that he had not made his meaning clear in the Paper did not quite fit in with the compliment that Mr. Lake had paid him concerning his ability to use the English language. The machine, he said, had a massive headstock, about 12 inches square, which slid up and down a column, and at the end of the headstock there was a circular saw driven by a motor. The casting to be dealt with was placed on a baseplate, and remained fixed throughout the operation, and the saw came down to the job. The saw was fixed horizontally, vertically or on the slant, for cutting off the head, according to its position on the casting.

MR. C. H. KAIN (Past Branch-President) asked to what extent the Sesci furnace was used in Continental steel foundries.

MR. FASSOTTE replied that one did not like to talk about one's own babies, but the furnace was being used regularly for the production of steel castings, though to a limited extent.

Mould Bonds

A SPEAKER asked whether Mr. Fassotte knew of any foundry using a green sand with a mixture other than water, which latter evaporated.

MR. FASSOTTE said he had not seen that.

MR. LAKE commented that the practice was very common in the earliest days of green sand.

MR. FASSOTTE said that silicate of soda was being used in connection with some cores and moulds, but that was no longer a green sand.

MR. LAKE recalled that a green sand which had been marketed as a proprietary article had been bonded with creosote.

MR. FASSOTTE said that organic bonds of the sulphite type were used extensively in core-making, but hardly ever in moulds.

The "Fischer Process"

The BRANCH-PRESIDENT asked if Mr. Fassotte could enlighten him by information concerning the "Fischer process," for he had heard much about its use for making steel castings in the United States during a recent visit there. Apparently the American naval authorities were very keen on the process, which he was told had originated on the Continent, apparently in Switzerland.

With regard to hydraulic fettling and the statement by Mr. Fassotte that a pressure of 50 atmospheres was required, the Branch-President said that obviously tremendous pressure was necessary for removing the sand which was burned on to steel castings; but the figure of 50 atmospheres was probably higher than was used in the case of cast iron, and he asked for a comparable figure applying to iron castings.

MR. FASSOTTE said he believed that the use of the term "Fischer process" was not quite correct, even though it might be used in the States. The Fischer foundry at Schaffhausen was a very fine foundry indeed, with a very good reputation, its products being known all over the world. He would not imagine that the Fischer people used just one particular process; they certainly possessed a very wide experience, and he presumed that the so-called "Fischer process" was rather a general practice operated under that firm's guidance by licence.

THE BRANCH-PRESIDENT said he had gathered that it was something of that sort.

MR. FASSOTTE added that there was a foundry in Italy, several in the States, and there might be others, working under the advice of the Fischer steel foundry. Presumably that fact was the origin of the expression "Fischer process."

Apparently he had not made himself clear in his reference to the use of a pressure of 50 atmospheres for the hydraulic fettling of steel castings; the same pressure was used on steel as on iron. The criticism levelled against this machine by the industry was that in the cleaning of steel castings, where core irons opposed themselves to the jet of water, the efficiency of the machine was reduced tremendously; probably the same objection did not apply to iron castings.

(*Concluded on page* 418.)

Patternmaking for Production Moulding

By S. A. HORTON

(*Concluded from page* 396.)

Hinge Bar (Type 2)

Fig. 12 shows a neutral stone-compound pattern equipment, with a twin-plate construction cast inside the two halves of a moulding box. The design of the casting involves a difficult mould joint, and it will be noticed that this difficulty has been successfully overcome. Two advantages of using this material are the short time it takes to construct a suitable pattern plate, and the ease with which intricate moulding joints can be produced. As this material does not contract or expand, plate patterns can be constructed from shell patterns with very satisfactory results. The casting weight is 14 lbs.

THE COREBOX AND CORES

The corebox used on production work suffers rougher usage than the pattern, so it is essential that the construction be as robust as possible. A very satisfactory method is to construct the actual corebox within a frame, this outer frame receiving the "rapping," and when it becomes mutilated, another frame can be easily made to replace the old and the actual corebox is not impaired.

Rear Axle Housing

The corebox illustrated in Fig. 13 shows the principle of its construction. The outer frame is strongly constructed, the ends being rebated into the sides and supported with battens at the four corners. The corebox is of hardwood construction, and the extra cost involved when compared with the softer woods is compensated by the extra service life; also, repairs are not so frequent. This corebox was made for an experimental design, and before it is put into production the loose pieces shown, which are at present made of hardwood, will be made of aluminium; moreover, brass strips will be rebated into the joint face of the two halves to maintain the correct core joint. This core is designed to be made in halves and jointed in the mould.

Differential Case

The frame form of construction can be applied to the majority of coreboxes. As an illustration, a sectional metal corebox constructed within a hardwood frame was exhibited, the four sections being worked loose to assist in the production of the core. The sections are lightened out when the metal thickness necessitates, and the metal sections produce the core, whilst the wooden frame withstands the "rapping."

All wooden coreboxes should be supported with battens strong enough to withstand any warping tendency of the timber from which the corebox is constructed. It is well known that when two pieces of timber are jointed together with one grain at right angles to the other, each piece tends to correct any warping of the other, and this principle is used very successfully in corebox construction. The fault is that sometimes the battens used are stronger than the corebox, with the result that if the batten warps the shape of the corebox is permanently altered.

A combination of hardwood and metal makes a very serviceable corebox. The main construction is of hardwood, and sheet brass facings are attached to all faces that will be strickled. It is surprising how quickly a wooden surface wears when repeatedly strickled. If the core is to be made in halves, brass strips can be rebated into the joint faces, the loose pieces being made of aluminium alloy. One advantage of having metal loose pieces is that, if necessary, they will withstand rapping and rough usage. The extended life which can be obtained by a suitable combination of wood and metal repays handsomely the cost involved.

Switch Box

When the design of a core necessitates the corebox being sectioned to release the core, it is sometimes constructed to part at diagonal corners. In order to secure the corebox when the core is being rammed, bolts pass through the sides holding the box in position; to assist in the easy removal of the core, wing nuts are fitted to the bolts. The robust construction is well shown in Fig. 14, the sides and ends being well battened. It is good practice to secure the battens very firmly in position, but they should not be glued because, under the adverse conditions that operate in a foundry, there will be slight movement of the timber and, when the battens are secured by screws, this slight movement can take place without any detrimental effects.

For correct core location it is essential that the portion which assembles in the coreprint be produced by the corebox. This may necessitate loose pieces in the corebox, but the results obtained justify the extra cost.

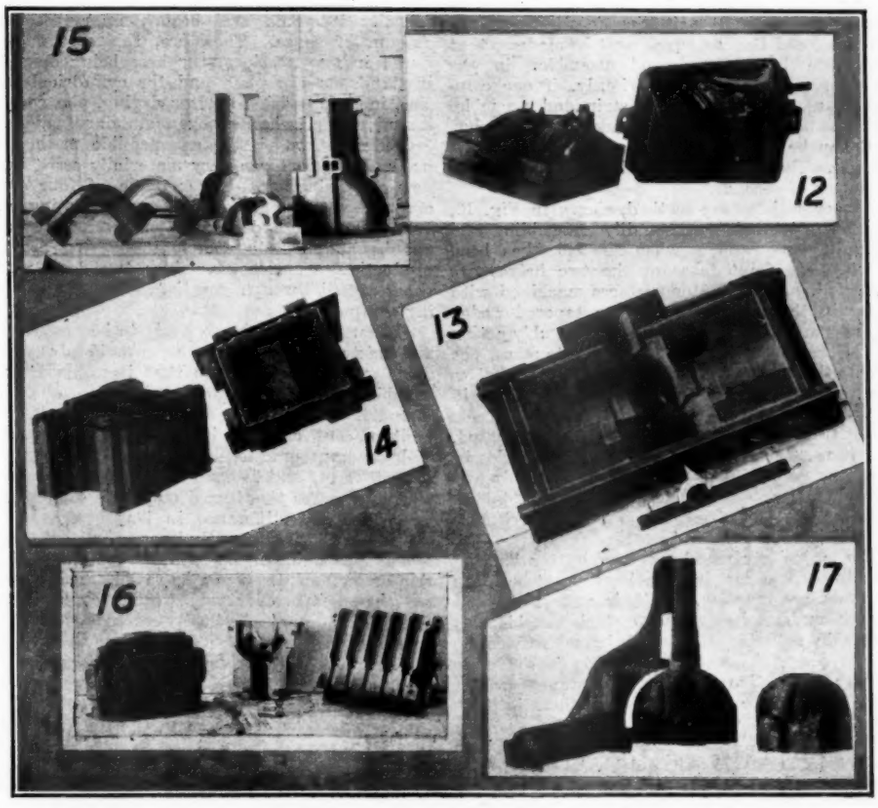
Square Box

Fig. 14 also shows a very good example of this, and illustrates these remarks. The four loose pieces are designed to form the taper of the coreprint; the taper of the core is in the opposite direction, and if loose pieces were not used the print taper would have had to be formed by the moulder when assembling the core, which is not a very satisfactory method.

There is an old foundry saying, "flash before a crush," but this does not apply to production moulding, and there is really no need for either, because both can be avoided with properly constructed equipment. This question of coreprint and core sizes is a very debatable one. It is a recognised principle of patternmaking that the print should be of dimensions suitable to support the core and maintain it in its correct position. It is very surprising to notice, when visiting various foundries, the vast difference there is in the size of coreprints. Some foundries produce satisfactory castings with what other foundries would consider very insufficient coreprint. This is another detail that must be left with each individual foundry to decide.

Coreprint Sizes

A very satisfactory method is to make the coreprint and corebox the same size, as pattern and corebox "rap" will produce a satisfactory clearance for the assembly of the core. By this method a correctly-made core to crush through fouling the mould has never personally been known. One patternshop of a production foundry known to the author made all coreprints to fit inside the corebox, and very successful results were obtained. Crushed moulds, due to cores being larger than the print, were very rare.



FIGS. 12-17.—REPRESENTATIVE PATTERNS FOR PRODUCTION MOULDING.

Metal Coreboxes

A metal corebox is either cast from a wooden master box or from a plaster of paris master box. Wooden master boxes are generally used when the necessary shape can be economically constructed by this method, but sometimes it is cheaper to construct a wooden matrix, of the shape of the required core, and to use this to produce a plaster corebox. This method is used to construct the corebox suitable for an exhaust manifold.

Both methods of construction are shown in Fig. 15. The wooden corebox has been lightened out to give a uniform metal section and the wooden matrix is shown in one half of the plaster box. The other plaster corebox illus-

trates how this method of construction is used in the production of a corebox with a very intricate joint.

Machining allowances are incorporated wherever possible to assist the metal patternmaker. As an exceedingly good finish is necessary on the unmachined surfaces, all loose pieces should be so formed that they are unmovable whilst the core is being rammed. The metal section must be strong enough to withstand the service conditions, but as light as possible to reduce the fatigue of the core makers.

Cast iron and brass are very suitable metals for the construction of metal coreboxes. Aluminium is too easily defaced, although when carefully used a corebox of this material gives useful service.

Blown Cores

The core-blowing machine is now a recognised part of the coreshop equipment, and it has necessitated the introduction of a special corebox. As core-blowing is primarily to assist production, it is not the slightest use having one of these machines unless it can be worked to capacity. Therefore, it is essential to have sufficient coreboxes continually to maintain the working of the machine, and the coreboxes must be made so that they can be stripped and assembled in the quickest possible time. Obviously, if one corebox requires one minute to strip and assemble, twice as many cores will be made with a corebox that can be stripped and assembled in one half-minute. The time taken to blow the core is only a matter of seconds.

A very satisfactory method, shown in Fig. 16, has been evolved for speedily assembling and stripping the corebox when the core has been blown. The joint faces of the two halves are extended, and the outer surfaces machined with taper in the form of a slide; a tapered wedge engages over these slides, and the assembly action of the wedge is more or less instantaneous, the release being much the same. The two halves are securely held when the core-blowing is in operation.

Rough usage cannot be entirely eliminated, and it is essential that the wedges and slides be as strong as possible. Quickness of assembly and stripping is necessary; consequently it is impossible to be too critical of how the corebox is used to obtain the quickest production.

The majority of coreboxes used on the blowing machines are of cast iron, and care must be taken in their construction, as it is important that smooth surfaces be produced. This considerably assists in reducing to the minimum the tooling of the cores, as speedy production is the main feature. Defective cores must be scrapped rather than attempts be made to rectify them by tooling.

The two faces of the corebox joint must be a perfect fit, or trouble will quickly be experienced due to the sand blowing through the joint. In a very short time there will be worn in each face a groove through which the sand will pass. All loose pieces should be a good fit in their seatings, because the pressure at which the sand is blown very quickly reveals defects of bad jointing.

Experience has proved that deep recesses or pockets at right angles to the flow of the sand into the corebox are sometimes loosely rammed. To overcome this defect an exhaust hole is placed at the end of the recesses to allow any excess air to escape (Fig. 16). To retain the sand the hole is covered with very fine gauze, and this method has very successfully overcome trouble caused by air pockets.

Constant examination is necessary to check at the commencement all defects that develop, because an undetected defect can very soon be the cause of a new corebox being needed.

Another method of increasing core production is to construct a number of coreboxes within the same framework, this number being dependent on the foundry's requirements.

The example in Fig. 16 illustrates the method of construction. The core-producing unit is of cast iron and is made from a plaster cast. All working surfaces are machined and the outside surfaces are lightened out to produce a uniform metal section of approximately ¼ in., which greatly reduces the weight. This core is very simple in design, but more intricate designs are produced with ease. The cores are produced on a "bumper," machine, and the time taken is very little greater than if one core was produced.

For production purposes, it is not always advantageous to produce a core in one piece; sometimes it is necessary because of core-drying space or equipment to produce a core in two or more portions. The problem must always be considered before commencing to construct a corebox. It is usually cheaper and easier to construct two separate coreboxes for a given core than to construct one corebox and afterwards find, when the casting is in production, that the corebox must be altered and sectioned to produce the core in two parts.

These remarks are illustrated by the examples shown in Fig. 17. The core would occupy a considerable amount of room in the core stove because of its height, and if made to dry horizontally it would still occupy an appreciable amount of space. Therefore, this core is produced in two portions, the base being dried as it stands on the plate and the cylindrical portion in a core drier. After drying, the core is assembled and checked by a standard gauge.

Consideration of the best possible method of producing a core can very materially assist even flow of production. For example, if four cores are necessary to produce a certain casting and one core through difficulties of production cannot be supplied to complete the set, casting production is spasmodic. Such trouble is sometimes caused through unsatisfactory core-producing equipment.

Similar cores which are likely to become mixed and mistaken for each other should always be made slightly different so that it would be impossible for the wrong core to be assembled in a mould. This at first may seem a difficult proposition, but actually it is not. The moulder with constant practice is used to assembling the correct cores, and if he receives a consignment of similar cores there need only be a very slight variation, *i.e.*, difference in length or size of coreprint, and he instantly knows the wrong core is being assembled. By this method a considerable amount of scrap can be saved. The author has had experience of wrong cores being assembled through similarity of shape and the same size of coreprint.

When, for purposes of accuracy, locations in the corebox are necessary, they should always be so placed to form a location that will not require tooling. In the majority of instances a core location that has been tooled is never as satisfactory as one produced by the corebox, and core misplacement can have a very serious effect on casting production.

The ideal pattern equipment is one that is continually in production producing perfect moulds and cores. A colleague, who has studied production moulding in the U.S.A., has stated that the pattern equipment used in that country is the finest he has ever seen, and that the mould, when the pattern has been withdrawn, requires no hand working. If a bad lift be experienced the mould is knocked out; from observation, however, bad lifts are very infrequent and, moreover, the moulders had no moulding tools.

He was informed that the patternshop always endeavoured to construct the finest possible equipment. Of course, there is a considerable difference in the number of castings produced from an individual design in this country compared with U.S.A.; hence, one cannot afford to lay out as much money on pattern equipment in this country, but with the general skill of the foundry deteriorating through the introduction of semi-skilled labour, the pattern equipment will have to be of a high standard to compensate for the loss of moulding skill. The patternshop must endeavour to supply the foundry with equipment so constructed that moulding skill of a high degree is not necessary, and in this manner will maintain within the craft the skill which the majority of other crafts are gradually losing.

In conclusion, the author wishes to thank the directors of Ley's Malleable Castings Company, Limited, for permission to photograph certain pattern equipment and for supplying the facilities used in the production of the illustrations, and Messrs. R. W. Williams, A. E. Peace and W. C. Marshall for their assistance in producing the lantern-slides.

Continental Steelfoundry Practice

(*Concluded from page* 416.)

Vote of Thanks

MR. V. C. FAULKNER, proposing a hearty vote of thanks to Mr. Fassotte for his Paper, said that it contained a wealth of interesting and utilisible information. In addition to the facility with which Mr. Fassotte had used the English language, a facility which Mr. Lake eulogised, the meeting must have also appreciated his profound knowledge of English practice. The members of the Branch and of the Institute were deeply indebted to him for having travelled from Belgium in order to present the Paper. The fact that he had so wide a knowledge of British practice had enabled him to give just the information most acceptable, and all members would look forward to the opportunity of studying the Paper again. He felt sure that no vote of thanks was ever better merited than that which he proposed to Mr. Fassotte.

MR. H. WINTERTON (Immediate Past-President of the Institute), seconding the vote of thanks, said that never before had the members of the Institute been favoured by a lecture from a Continental visitor delivered in such excellent English and conveying so many English thoughts.

Commenting upon the point raised by Mr. Deschamps, as to why the German founders heated their chamotte, Mr. Winterton said that presumably they did so for the same reason that the manufacturer of compositions in this country heated his silica, *i.e.*, to reduce the danger of shrinkage and to increase the refractoriness.

MR. C. W. BIGG (President of the Institute) supported the vote of thanks, which was accorded with enthusiasm.

MR. FASSOTTE, in a brief response, said that the reception accorded him was another example of the numerous kindnesses to which his English friends had accustomed him.

Soviet Iron and Steel Industry

The output of the Soviet iron and steel industry was unsatisfactory in the September quarter, and actual production is substantially below the plan figures. Only 67.5 per cent. instead of 75 per cent. of the planned tonnage of pig-iron for 1937 (16,010,000 tons) was made in the period January to September. Only 10,800,000 tons were made, against 10,740,000 tons in the parallel period of last year, the actual increase being 0.6 per cent., against a planned increase of 11.1 per cent. Steel output this year was planned to be 20,150,000 tons, but only 64.5 per cent. of this total was produced in the first nine months. The actual tonnage made was 13,000,000, compared to 11,920,000 tons in the parallel period of 1936, the effective increase being 9.1 per cent. against 23.6 per cent. planned. The output of rolled products presents a still more unsatisfactory picture, for of the annual plan of 15,620,000 tons, only 61.4 per cent. had been produced by the end of September; the actual output was 8,590,000 tons, against 8,920,000 tons in the parallel period of last year, an increase of 7.5 per cent. against a planned advance of 25.5 per cent. The low figures for the nine months are in each case due to the decline in output in the third quarter as compared with the June quarter of this year.

The Classification of Foundry Sands*

By T. R. WALKER

During recent years in industry the requirements from the products have been gradually increased. This applies to almost every phase of manufacturing activity, including that of castings manufacture. In the foundry, larger outputs are required of castings with improved physical properties and a better surface. The increased requirements have made it necessary to control industrial operations more closely, and nowhere is this more evident than in the foundry. In a modern foundry, to obtain success every operation and every material must be controlled. These materials include sand, and it is a matter of common knowledge that during recent years the testing of sand on a scientific, or semi-scientific, basis, has made rapid progress. The apparatus used in sand testing is finding its place in more and more foundries, and the results obtained from such testing are understood throughout the foundry world.

Sands to Specification

In considering the results of sand testing, it is necessary to remember that uniformity is quite as important as the actual result obtained. In order to obtain uniformity in the sands coming into a foundry, from which the sand mixtures used for moulding or core making will be made up, it is necessary for someone, either the supplier or the consumer, to test the sands to ensure that their properties do not differ more than a reasonable amount from the average of the supplies. This means that in time a consuming firm will wish to receive sands within a certain range of properties, the range having been found as the result of foundry experience with the raw sands supplied. More than one supplying firm is, in fact, now prepared to supply sands to specifications.

If the construction of these specifications is left to the consuming firms, each one would in time evolve close specifications of sands to meet their requirements, and it is very unlikely that foundries even engaged in manufacturing the same class of casting would hit on identical specified ranges for the properties of the sands they require. There would thus gradually be constructed a large number of specifications, many of them differing only very slightly, and this would involve the supplying firms in considerable difficulty, since sands which would meet the specification of one foundry would not quite meet that of another foundry, even though actually the same sand would be equally suitable in the two foundries.

In order to avoid this prospective state of confusion and difficulty, it would be far better to classify the foundry sands available as raw materials, or supplied ready for use, by dividing them into groups. If the range of properties within each group was not too closely specified, the selection of a group would be quite as valuable as the meeting of a specification, since it would cover the requirements of a number of specifications varying very slightly in details. If the range of properties within each group was not too wide, sands in the same group would for many foundry purposes be equivalent, so that the choice of a sand would be simplified and not complicated.

Variety of Properties

Most of the important properties which affect the foundry behaviour of a sand can now be assessed with comparative ease and rapidity. They include the chemical analysis, the size, shape and surface of the grains, the green and dry strength, and the permeability. Since the strength and permeability are greatly affected by the amount of water present, the water content is an important property to be determined. It must be emphasised that the results of the tests itemised are not sufficient to determine completely the foundry behaviour of a sand, but precisely the same remark applies to any more complete examination which can be carried out at present. The final evaluation of a sand must be made as the result of foundry experience, but sand testing gives very valuable assistance in the choice of a sand likely to give good results.

In the proposed classification each significant property of the sand is divided into ten groups, each group covering a definite range of values, the ten groups covering the usual properties of sand, ranging from strong natural moulding sands to silica sands, and the proposed system of classification is set out in Table I.

A Simplified Classification

In the classification, the properties specified have been cut down in number to a minimum in order not to make the scheme complicated. The chemical analysis, for example, includes only silica, alumina and ferric oxide, these being the principal constituents which determine the foundry behaviour of a sand. The water content of a sand alters its properties enormously.

It is not possible to fix a water content which would suit all types of sand, but fortunately there is an optimum, or best water content, at which any sand will develop the best green strength, and this optimum water content has, therefore, been chosen as the property to be specified. It is understood that the maximum permeability will, in general, not coincide with the water content at which the green strength is a maximum, but usually the two water contents are reasonably close together. The water content has been included in the chemical analysis group of classification, since its determination is essentially a chemical matter.

For the mechanical grading, Boswell's classification has been adopted as being the minimum which can be utilised to supply useful information regarding the distribution of grain sizes. The particle sizes corresponding to the grades are as follow:—

Very coarse sand	1 to 2 mm. dia.
Coarse sand	0.5 to 1 ,,
Medium sand	0.25 to 0.5 ,,
Fine sand	0.1 to 0.25 ,,
Silt	0.01 to 0.1 ,,
Clay	less than 0.01 ,,

The green strength grouping calls for no particular mention, except that it must be remembered that the green strength is the maximum which can be obtained, this, of course, depending on the water content. The dry strength depends not only on the nature of the sand, but also on the water content; the dry strength figure mentioned in the classification is that obtained by drying a green sample containing the optimum water content. It is naturally possible to obtain higher dry strengths than this by increasing the green water content, this at the same time diminishing the green strength. The grouping of permeability figures offers no particular difficulty.

Grain-Shape

In considering the grains, the important features are the shape, which may be rounded or angular to different extents; the nature of the surface, which may be either smooth, rough or pitted; and the presence or absence on the washed grain surfaces of a thin film of secondary bond tenaciously held. These points have, therefore, been covered in the classification, whilst the size distribution of the grains has already been covered in the mechanical grading.

TABLE I.—*Classification of Sands into Groups.*

Group No.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
Chemical Analysis—										
SiO_2 .. .. per cent.	Up to 81	Over 81 To 83	Over 83 To 85	Over 85 To 87	Over 87 To 89	Over 89 To 91	Over 91 To 93	Over 93 To 95	Over 95 To 97	Over 97
Al_2O_3 .. .. ,,	Up to 2	Over 2 To 4	Over 4 To 6	Over 6 To 8	Over 8 To 10	Over 10 To 12	Over 12 To 14	Over 14 To 16	Over 16 To 18	Over 18
Fe_2O_3 .. .. ,,	Up to 2	Over 2 To 4	Over 4 To 6	Over 6 To 8	Over 8 To 10	Over 10 To 12	Over 12 To 14	Over 14 To 16	Over 16 To 18	Over 18
Optimum water content .. ,,	Up to 2	Over 2 To 3	Over 3 To 4	Over 4 To 5	Over 5 To 6	Over 6 To 7	Over 7 To 8	Over 8 To 9	Over 9 To 10	Over 10
Grading—										
V.C.S. .. .. per cent.	Up to 5	Over 5 To 10	Over 10 To 15	Over 15 To 20	Over 20 To 30	Over 30 To 40	Over 40 To 50	Over 50 To 60	Over 60 To 70	Over 70
C.S. .. .. ,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
M.S. .. .. ,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
F.S. .. .. ,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
Silt .. .. ,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
Clay .. .. ,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
Green strength (lbs. per sq. in)	Up to 1	Over 1 To 5	Over 5 To 10	Over 10 To 15	Over 15 To 20	Over 20 To 25	Over 25 To 30	Over 30 To 35	Over 35 To 40	Over 40
Dry strength .. (lbs. per sq. in.)	Up to 20	Over 20 To 40	Over 40 To 60	Over 60 To 80	Over 80 To 100	Over 100 To 120	Over 120 To 140	Over 140 To 160	Over 160 To 180	Over 180
Permeability No.	Up to 25	Over 25 To 50	Over 50 To 100	Over 100 To 150	Over 150 To 200	Over 200 To 250	Over 250 To 300	Over 300 To 350	Over 350 To 400	Over 400
Grains clean	Not clean	Rounded smooth	Rounded rough	Rounded pitted	Sub-angular smooth	Sub-angular rough	Sub-angular pitted	Angular smooth	Angular rough	Angular pitted
Grains with secondary bond	No bond	,,	,,	,,	,,	,,	,,	,,	,,	,,

* A Paper read before the Sheffield Branch of the Institute of British Foundrymen, Professor Andrew presiding.

In writing down the classification of a sand from its determined properties, the results are set out in three rows of figures. The first of these, called for convenience A, refers to the chemical analysis, including water content. The second, called B, refers to the mechanical grading, and the third, called C, covers green and dry strength, permeability and nature of the grain. If the properties of a sand are known, to determine the number of the group to be allocated for a given property, it is necessary only to compare the determined value for that property with the range covered by the different groups of that property. For example, if the silica content of a sand is 92 per cent., then, since the group covering the range of 91 to 93 per cent. silica is group 6, this 6 is the first figure to be set down in row A. Similarly, if the alumina content is 7 per cent., then the second figure in row A will be 3, since group 3 covers alumina contents of 6 to 8 per cent. The figures for the other properties are obtained in precisely the same way, so that finally all the properties covered in the classification are expressed in three rows of numbers.

Practical Examples

One or two detailed examples will make the application of the system quite clear. Suppose a moulding sand, as the result of examination, gives the following results:—

Chemical Analysis—

SiO_2	91.5 per cent.
Al_2O_3	6.7 ,,
Fe_2O_3	1.4 ,,
Optimum water content	6.2 ,,

Grading—

V.C.S.	2 per cent.
C.S.	3 ,,
M.S.	48 ,,
F.S.	27 ,,
Silt	6 ,,
Clay	14 ,,
Green strength	5.5 lbs. per sq. in.
Dry strength	110 ,, ,,
Permeability No.	130
Grains	Clean, sub-angular, rough.

Comparing these properties with the table, they can be written down as follow:—

A	6 3 0
B	0 0 6 4 1 2
C	2 5 3 5

Supposing now that one is given the figures in rows A, B and C above and works backwards, it is found that the figures describe a sand having the following properties:—

Chemical Analysis—

SiO_2	91 to 93 per cent.
Al_2O_3	6 to 8 ,,
Fe_2O_3	Not more than 2 per cent.
Optimum water content	6 to 7 per cent.

Grading—

V.C.S.	Not more than 5 per cent.
C.S.	Not more than 5 per cent.
M.S.	40 to 50 per cent.
F.S.	20 to 30 ,,
Silt	5 to 10 ,,
Clay	10 to 15 ,,
Green strength	5 to 10 lbs. per sq. in.
Dry strength	100 to 120 ,, ,,
Permeability No.	100 to 150
Grains	Clean, sub-angular, rough.

This range of properties indicates at once the type of sand described. It is evidently a moulding sand suitable for facing purposes on medium size castings. If a supplier were asked to supply such a sand, he would probably be unwilling to reduce the range of values indicated, so that in effect the range given embodies a specification.

A Second Example

As another example, supposing one is given the classification of a sand as follows:—

A	9 0 0 0
B	0 1 8 4 0 0
C	0 0 9 1

The first row A tells us that the silica content is over 97 per cent.; the sand is evidently a silica sand with little iron or alumina present. This is confirmed by the optimum water content, which is not more than 2 per cent. From the grading it can be seen that since the medium sand grade is between 60 and 70 per cent., the sand is a coarse silica sand. The fact that it is a silica sand is again confirmed by its green strength, as shown in row C, which is not more than 1 lb. per sq. in., and its dry strength, which is not more than 20 lbs. per sq. in. The fact that it is a coarse silica sand is also confirmed by its permeability, which is indicated as being over 400. It is also revealed that the grains are clean, rounded and smooth. Setting out the information deduced from the classification gives us the following table:—

Chemical Analysis—

SiO_2	Over 97 per cent.
Al_2O_3	Not over 2 per cent.
Fe_2O_3	,, 2 ,,
Optimum water content	,, 2 ,,

Grading—

V.C.S.	Not over 5 per cent.
C.S.	5 to 10 per cent.
M.S.	60 to 70 ,,
F.S.	20 to 30 ,,
Silt	Not over 5 per cent.
Clay	,, 5 ,,
Green strength	,, 1 lb. per sq. in.
Dry strength	,, 20 ,,
Permeability	Over 400
Grains	Clean, rounded, smooth.

From the figures given there is no doubt whatever of the kind of sand described, and there is equally no doubt that for all practical purposes in the foundry such a sand could be obtained from more than one supplier and from more than one district.

The advantages of a classification of this kind need no elaboration. Its adoption would assist suppliers and consumers alike. The supplier would, in effect, be supplying sand to meet a specification not to suit a single consumer but acceptable to a number of foundries, and the examination of his raw materials to ensure that their properties complied with the particular groups selected would give him timely warning of any change in the nature of the deposits. The consumer would receive sands the variation in whose properties was limited to known amounts, whilst the knowledge of the variation in properties permissible in a particular sand would allow the selection of alternative sources of supply which might be more economically situated.

"Lindewelding"

The third of a new series of technical information booklets issued by the British Oxygen Company, Limited, Thames House, Millbank, Westminster, S.W.1, deals with a method of welding which is intended for specialised work. The work envisaged is the butt welding of steel pipes, and experience has shown that the adoption of this method will bring with it a saving in cost and an increase in efficiency. The method is known as "Lindewelding," and it involves the welding of steel at a temperature below its melting point. The method has been in existence for some time and has reached a stage of an advanced development. The advantages of "Lindewelding" include the increase in speed of welding; the absence of harmful heat effects on the parent metal and the extremely small transformation zone. Not only does the parent metal remain below 1,200 deg. C., even right up to the weld itself, but it remains unchanged in structure to within a fraction of an inch from the weld. The method requires no special equipment, but the best results are obtained by using a multi-flame blowpipe nozzle. This type of nozzle has naturally a greater hourly consumption of fuel gases than the ordinary type of nozzle, but the consumption per foot of weld is actually less owing to the greater speeds of welding. A special rod must be used, which contains self-fluxing elements, and which gives incidentally excellent mechanical properties. So far the technique is restricted to the butt welding of steel pipes in a horizontal plane.

Deterioration of Steel under Service Stresses

MR. R. A. MACGREGOR (Chief Metallurgical Inspector, Government of India, Jamshedpur) recently read a Paper on "Deterioration of Steel under Service Stresses" before the Mining and Geological Institute of India, held at Jamshedpur, in the course of which he said that steelmakers regularly received broken steel parts for investigation. In the course of his work he had estimated the percentage of engine parts which had broken down, and found that on a basis of a quarter of a million tons of assorted engine forgings there was something less than 1 per cent. of reported failures.

General experience of service failures had shown that in only a very few cases could poor quality or steel defect be blamed. One authority published the statement that 10 per cent. only of failures could be traced to steel defect; the other 90 per cent. were unquestionably due to the engineer's misuse of the material.

Continuing, the speaker said that the oldest and most persistent of the misconceptions prevailing among engineers was that having to do with deterioration in the course of time, under service stresses. Some parts broke down in a few months, indicating bad or unsuitable material; some parts broke in a few years, showing that they were probably made of steel not so good in quality as those which lasted longer. It had been fashionable for a long time to attribute the failures to the gradual exhaustion of the steel's properties, so, in the complacency of his 99 per cent. successes, the engineer had had a seemingly sound reason for the failure of the remaining 1 per cent.

It was most fortunate that design should have been based, three-quarters of a century ago, on a fraction of the tensile strength which ensured working within the yield point, and which happened to be within the, as yet, undiscovered fatigue limit. At the same time, it was unfortunate that this rule of design should have been so successful in that it led to the firm belief that deterioration was the explanation of all failures.

The foregoing did not include those cases where design stresses were below the yield point, but above the fatigue limit to such an extent that the survival of the part was solely due to the fact that the number of service reversals of stress was so low that the fatigue life or endurance was greater than its life under other conditions. In these cases the least departure from ideal conditions was followed by failure in a year or two.

Really practical research into the strength of steels under different conditions of loading only came into being about 16 years ago, and one of the first results was to explode the long-established idea of deterioration or exhaustion in the course of time, under stresses below the yield stress. Every investigator has shown that steel has a fundamental property known as the fatigue limit, of being able to withstand an indefinitely large number of reversals of stress up to a well-defined maximum.

There were, however, various conditions which profoundly modified that figure, and it was to that fact that most of the failures in service could be ascribed. No designer knowingly arranged for his structures to be loaded in such a way that the resulting stress was sufficient to cause breakdown. Or even if his sections were dictated by past practical experience, rather than accurate calculation, it was not to be expected that normal service conditions would result in failure. It was to these modifying conditions that one must look for an explanation of breakdowns for, as had already been shown, it was only on rare occasions that the steel itself was found to be at the root of the trouble.

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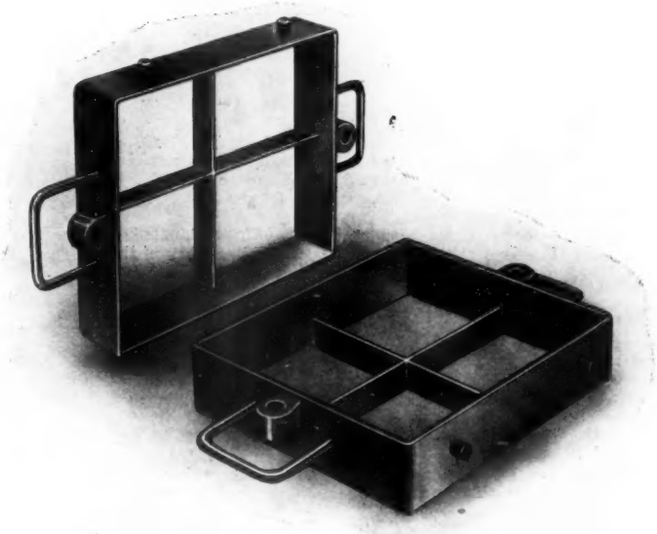

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The Week's News in Brief

Trade Talk

SIR CHARLES WRIGHT, BT., chairman of Baldwins, Limited, opened last week an extension to the Panteg House Institute for the employees of the company.

THE KEEL was laid at the Barrow yard of Vickers-Armstrongs, Limited, recently of the aircraft carrier "Indomitable." She will be the longest vessel built at Barrow.

HARLAND & WOLFF, LIMITED, are building a new patternshop at their Clyde Foundry at Govan. The present shop is insufficient to cope with the large amount of work being dealt with.

THE ENGLISH STEEL CORPORATION, LIMITED, has received an order for special alloy-steel high-pressure vessels for a hydrogenation plant in Italy. A similar order was placed with the Corporation a year ago.

THE RIGHT HONOURABLE J. H. THOMAS, P.C., is to be the principal guest at the Annual Dinner of the London Branch of the Institute of British Foundrymen, which will be held at the Charing Cross Hotel, London, on Friday, December 3.

THE AUSTRALIAN STEEL ALLOY COMPANY, LIMITED, Sydney, has signed agreements with leading American steelworks under which the Australian company will manufacture products which have been hitherto imported from the United States. A new works is to be erected in Sydney.

THE INDUSTRIAL WELFARE SOCIETY is to hold a dinner at the Hotel Victoria, Northumberland Avenue, London, on Tuesday, December 7, when the chairman of the Council, Commander Sir Charles Craven, will preside. The speakers will include the Rt. Hon. Sir Thomas Inskip, Sir James Lithgow, Bt., and Mr. J. W. Bowen.

A PARTY from the Sheffield University Metallurgical Society, under the leadership of their secretary, Mr. L. Mullins, paid a visit to the Huddersfield works of David Brown & Sons (Hudd.), Limited, on November 10, inspecting the all-electric heat-treatment department, the bronze foundry, and departments dealing with the production of marine and rolling mill gear drives.

A PARTY of over 200 visitors from London and the Provinces were the guests of the Chloride Electrical Storage Company, Limited, of Clifton Junction, near Manchester, last Friday, when they inspected the works where the well-known Exide batteries are made. Of special interest was the moulding department, in which the antimonial-lead plates for batteries are die-cast. There are over 800 different types and sizes of these plates, and all the necessary permanent moulds are produced in the well-equipped machine shop attached to the works.

THE MANCHESTER ASSOCIATION OF ENGINEERS will hold its annual Conversazione and Dance in the College of Technology, Sackville Street, Manchester, on Saturday, December 18. The programme will include features which have been very popular in the past—an organ recital during the reception; dancing in the Great Hall throughout the evening; short concerts and, by special permission, the ever-popular demonstration and Christmas display in the bakery. The display of cinematograph films and a scientific and technical exhibit will be also included. Full details of the function can be obtained from the secretary, Mr. T. Makemson, St. John Street Chambers, Deansgate, Manchester, 3.

ON NOVEMBER 17 the well-known firm of refractory brick makers, John G. Stein & Company, Limited, Bonnybridge, attained its jubilee. The firm was founded in 1887 by the late John G. Stein at High Bonnybridge, and has steadily grown from modest beginnings until at the present time, with works at Denny, Manuel, Bonnybridge and Castlecary it has a weekly output of high-grade firebricks of over a million. On the death of the founder the management passed to his two sons, Colonel Alan Stein, M.C., D.L., who is chairman and managing director, and Mr. Norman Stein. The same progressive policy was maintained, and an elaborate research laboratory was started. To celebrate the jubilee the firm has presented a bonus to every employee who has completed more than one week's service with the firm. Those with over a year's service have received a week's pay; those with over 6 months, 3 days' wages; and those with over a week's service, one day's wages.

Personal

MR. A. DUNLOP, metallurgist to Steven & Struthers, brassfounders, of Glasgow, has resigned upon being appointed to a position in the research department of the Mond Nickel Company, Limited, in Birmingham.

MR. A. N. SUMNER, who has been an assistant in the laboratory of Glenfield & Kennedy, Limited, for some time, has been appointed chief assistant metallurgist to Ransomes & Rapier, Limited, Waterside Works, Ipswich.

MR. PARLANE M'FARLANE, who has been foundry manager of Shaw (Glasgow), Limited, Maryhill Ironworks, Glasgow, for over 33 years, has retired on account of health reasons. He has been presented with a silver tea service and salver from the employees.

Obituary

DR. PAUL GRÜNFELD, the founder and director of Gesellschaft für Elektrometallurgie, Berlin-Charlottenburg, died of heart failure on November 13.

MR. FRANK MILWARD WRIGHT, for many years London manager of the iron department of the Sheepbridge Coal & Iron Company, Limited, died on Wednesday, November 17.

SIR SEYMOUR TRITTON, a Past-President of the Institute of Locomotive Engineers, and a partner in the firm of Rendel, Palmer & Tritton, consulting civil engineers, died in London last Sunday, aged 75 years.

MR. ARTHUR MILDREN, a member of the South African Branch of the Institute of British Foundrymen, and foreman patternmaker with Rowe, Jewell & Company, Limited, engineers and founders, of Johannesburg, died recently. He had been associated with the firm for nearly 25 years.

Company Reports

Dunswart Iron & Steel Works, Limited.—Final dividend of 8 per cent. on the ordinary shares, making 14 per cent. for the year ended June 30, 1937.

Atlas Steel Foundry & Engineering Company, Limited.—Final dividend of 10 per cent., plus a bonus of 10 per cent., making 30 per cent. for the year.

Stewarts and Lloyds of South Africa, Limited.—Dividend at the rate of 6 per cent. per annum on the first cumulative preference shares for the half-year to December 31.

Enfield Rolling Mills, Limited.—Net profit for year ended September 30, after transferring £12,559 from share premium account, of £41,074, reducing the debit balance to be carried forward to £30,889. Meeting, November 26.

Dorman, Long & Company, Limited.—Preliminary figures for the year ended September 30 last show:—Net profit, £1,375,418; to depreciation, £300,000; to general reserve, £200,000; taxation, £152,208; dividends of 18 per cent. on the preferred ordinary and 10 per cent. on the ordinary shares; carried forward, £152,130.

Whitehead Iron & Steel Company, Limited.—Profit for the half-year to September 30, 1937, after providing for all charges and contingencies, and setting aside £12,500 for depreciation and £56,000 as provision for income-tax and N.D.C., amounts to £157,000; an interim dividend of 12½ per cent. will be paid on December 8.

Brown, Bayley's Steelworks, Limited.—Profit for year to July 31, £138,368; brought in, £20,124; dividend on the cumulative preference shares for the two years to July 31, 1937, £50,000; dividend of 10 per cent., free of tax, on the ordinary shares, £30,000; to general reserve, £25,000; to reserve for obsolescence, £25,000; carried forward, £28,492.

UNITED ENGINEERS, LIMITED, Singapore, made a net profit in the year ended June 30, 1937, after making provision for depreciation, of $508,646. A dividend of 10 per cent. has been paid on the ordinary shares.

Foundry Trades' Exhibition

F. W. Bridges & Sons, Limited, of Grand Buildings, Trafalgar Square, London, W.C.2, organisers of the Foundry Trades' Exhibition, have addressed the following circular letter to the trade:—

Foundry Trades' Exhibition

SIR,—With regard to the above exhibition, I feel that a situation has developed which merits the close attention of interested parties, and I would crave of your indulgence for a moment briefly to state the history of pertinent events.

Three Foundry Trades' Exhibitions were held under the management of this company at the Royal Agricultural Hall in the summers of 1926, 1929 and 1933. Of these only the exhibition in 1929, held in conjunction with an International Foundry Convention, can be considered to have been reasonably representative, and the falling-off of exhibits, especially in the heavy classes, at the 1933 exhibition led to a change of policy whereby the Foundry Exhibition was embodied with the Shipping, Engineering and Machinery Exhibition in 1935, and, as it then became known, the Engineering and Marine Exhibition held in September this year. It must be admitted that in neither of these two last-named events was the foundry equipment, as distinct from the supplies industry, satisfactorily represented.

The next of the Olympia exhibitions is due to be held in September, 1939, and in that year, also, there is to be, after an interval of ten years, another International Foundry Convention in London, the date for which, I believe, has been fixed for June. It is obvious that this opens the way to a variety of policies with regard to future Foundry Trades' Exhibitions, including the possibility of staging, once again, a separate exhibition in the Royal Agricultural Hall to coincide with the International Convention in June, 1939.

With the object of securing the fullest and freest possible discussion on the whole matter, I am asking representatives of the leading interested parties, both members and non-members of the Foundry Trades' Equipment and Supplies Association, to meet me at luncheon at the Hotel Victoria, Northumberland Avenue, London, W.C.2 (or such other place as may be necessary) one day during the week commencing Monday, December 6, 1937, at 1 p.m. for 1.15 p.m. In order to secure the maximum attendance I am enclosing a reply sheet offering a choice of four days in that week [the dates given are December 6, 7, 8 and 9], and on receipt of the replies I will then send a further confirmatory notice of the day selected as being convenient to the greatest number.

Trusting that you will co-operate with me in this honest endeavour to find the most satisfactory solution to a somewhat complicated problem, yours, etc.,

K. W. BRIDGES
(Director, F. W. Bridges & Sons, Limited).

Forthcoming Events

DECEMBER 2.

Institute of Metals (Birmingham Section):—"Bright Annealing," open discussion, at James Watt Memorial Institute, Birmingham, at 7 p.m.

Institute of British Foundrymen

DECEMBER 1.

Lancashire Branch:—"Production of Some Intricately-Cored Ferrous Castings," prize-winning Paper in Coronation Competition, by T. R. Harris, at Engineers' Club, Albert Square, Manchester, at 7.30 p.m.

DECEMBER 2.

Sheffield and District Branch:—"Some Notes on the Properties of Chilled Shot and Grit as used for Shot Blasting," Paper by J. E. Hurst and J. H. D. Bradshaw, at Royal Victoria Hotel, Sheffield, at 7.30 p.m.

DECEMBER 3.

Birmingham, Coventry and West Midlands Branch:—"Trend of Research on Foundry Matters," Paper by G. L. Bailey, M.Sc., at James Watt Memorial Institute, Great Charles Street, Birmingham, at 7.30 p.m.

London Branch:—Annual dinner, at Charing Cross Hotel, London, W.C.2, at 7 p.m.

The Institute of Vitreous Enamellers

DECEMBER 1.

Southern Section:—Joint meeting with Society of Glass Technology; "Optical Aids to the Enamelling Industry," Paper by A. H. Willoughby, and "Decoration of Milk Bottles using Vitreous Enamels," Paper by H. L. Crook, at Science Museum, South Kensington, at 7.30 p.m.

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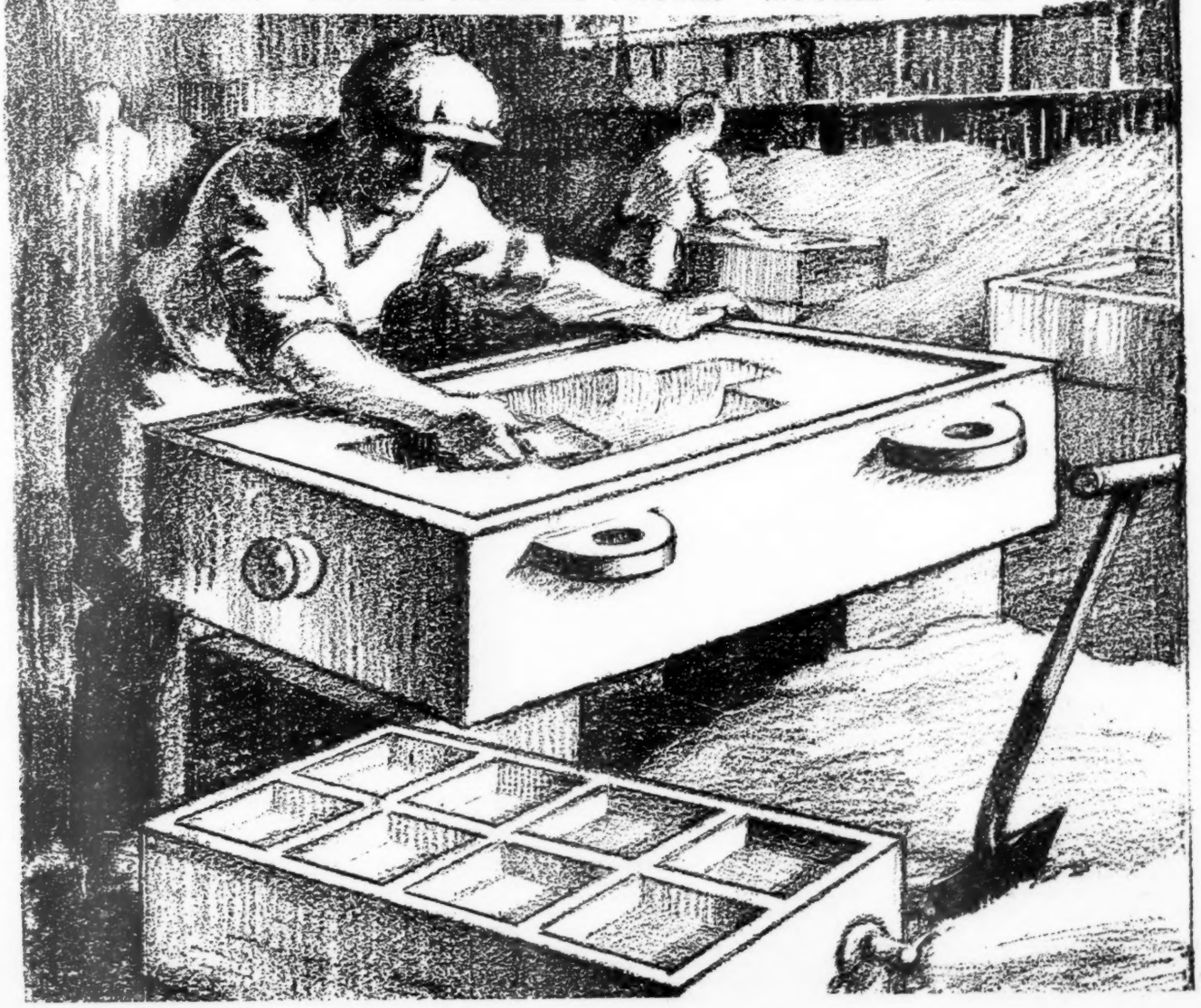


Raw Material Markets

Makers of foundry and forge pig-iron having a phosphorus content of 0.75 per cent. and upwards have decided to stabilise their present prices for the first six months of 1938, an exception being prices of Cleveland iron for delivery on the North-East Coast, which will be advanced by 3s. on January 1. Prices for other zones will remain unchanged. This decision of the pig-iron makers has been well received. Consumers both of iron and steel will be more willing to place their inquiries now that prices for 1938 are on a fixed basis. Producers' capacity for entering into new business is limited, but a substantial amount of trade is expected to be transacted.

Though, with the exception of the Middlesbrough area, prices of ordinary foundry numbers will be unchanged over the first half of next year, there are some adjustments. Silky foundry iron, *i.e.*, iron high in silicon, will be 1s. over the price of No. 3. Iron for puddling will be only 3s. below No. 3 foundry, and not 5s. as hitherto, while forge iron used in foundries will be 1s. below No. 3, instead of 3s. below.

The hematite makers also have announced their decision regarding 1938 prices. An increase of 10s. per ton (in the case of South Wales 7s. 6d. for pig-iron arising in that area) will be made on January 1 next on the basis price for mixed numbers, and there will be increases in the extras for special qualities of 4s. 6d. for 0.03 per cent. S and P, 6s. 6d. for 0.025 per cent. S and P, and 8s. 6d. for 0.02 per cent. S and P. These prices will hold until December 31, 1938. The increased cost of raw materials has fallen with particular severity on the hematite pig-iron industry and has necessitated this increase of prices.

Pig-Iron

MIDDLESBROUGH.—Consumers of pig-iron are gratified that producers have announced their intention with regard to next year's prices, and are eager to cover their requirements for as much of the six months allowed by the decision as possible. The recently-imposed loyalty rebate scheme has put a stop to the further use of French and Belgian irons, and it is fortunate that Midland ironmakers are better able to accept inquiries. For delivery in the Middlesbrough area until the end of December, No. 3 Cleveland G.M.B. is quoted at 106s., with Falkirk deliveries at 109s., less 5s. per ton rebate. Middlesbrough deliveries will be 3s. higher after December 31. Hematite output continues to be heavy, but much of it is consumed by the producers themselves, and the demand for the surplus is substantial. Prices are nominal at 122s. 6d. on the North-East Coast, 128s. in Sheffield, and 133s. 6d. in the Midlands, less 5s. per ton rebate, at which level they will remain until the end of the year.

LANCASHIRE.—Only a restricted amount of new business can be considered now that the price position has been cleared up, as makers' delivery arrears are still quite heavy. The demand lately has been less insistent, but it will be interesting to see the effect of the price decision. For delivery to users in the Lancashire price zone up to the end of the first half of next year, Derbyshire, Staffordshire and Lancashire brands of No. 3 foundry iron are quoted on the basis of 114s., with Northants at 112s. 6d. and Derbyshire forge iron at from 109s. to 111s. per ton, according to the class of consumer. Hematite prices are unchanged at 131s. for West Coast material, with East Coast at 130s. 6d., delivered Manchester and district.

MIDLANDS.—Pig-iron supply is ample fully to satisfy the demand in this area, and orders have even been accepted from consumers in other districts. Thus, a large amount of business should go through now that prices have been fixed over the first half of next year. Northants No. 3 is quoted at 108s. 6d. per ton for delivery to Birmingham and Black Country stations, with Derbyshire, Lincolnshire and North Staffordshire No. 3 at 111s. In view of ore and freight charges, it is likely that quotations for special iron will be advanced as from the end of the year. The demand is heavy. Low-phosphorus iron ranges in price from £6 7s. 6d. to £6 15s. 6d., with Scottish iron at £7 10s. and refined iron at a minimum of £8 2s. 6d. per ton. Little business is being done in Scottish iron, owing to the high price. The shortage of hematite is acute, and it is unlikely that much new business will be transacted even now the new prices are announced. For delivery up to the end of the year in Birmingham and district, East Coast No. 3 is quoted at £6 13s. 6d. and West Coast mixed numbers at £6 14s. 6d., with 1s. 6d. per ton extra if delivered to works.

SCOTLAND.—Although deliveries of pig-iron have generally been satisfactory, consumers are keen to increase their period of cover now that prices have been fixed. No. 3 Scottish foundry iron is quoted at 118s. f.o.t. furnaces, with No. 1 at 120s. 6d. Light-castings foundries appear to be quieter than ever. Imports against old contracts are still arriving, and consumers would no doubt like to purchase still more iron from abroad, but they are adhering to the loyalty rebate scheme. Mixed numbers of Scottish hematite are quoted at 123s.; Scottish basic, 107s. 6d.; English and Indian basic, 100s.; all less 5s. rebate, delivered steelworks here. Local steelworks are accepting heavy deliveries of basic, hematite and scrap. New business in basic is negligible, although the prices have been fixed up to June next.

Coke

Efforts to obtain a stable price for blast-furnace coke continue to be made. In most cases consumers on the foundry-coke market have contracted for their requirements until March, and generally are not disposed to book further ahead than that period. For delivery to Birmingham and district, best Durham coke is quoted at a minimum of 55s. 9d., with Welsh coke at from 55s. to 65s. per ton.

Steel

Steady conditions have developed in the steel market with the approach of the end of the year, says the official report of the London Iron and Steel Exchange. The volume of new business is somewhat restricted, largely because the producers are occupied in overtaking arrears of deliveries rather than undertaking fresh commitments. Consumers are pressing for deliveries against current contracts, and are not anxious to place orders for far forward delivery. Buyers still find it difficult to place orders for early execution, although the situation in this respect has become easier in some departments. In the semi-finished steel department, the expansion of the British production has eased the situation, while larger imports from the Continent have also assisted to relieve the difficulties of consumers. There is still, however, a gap between the available supplies and the requirements of the consuming industries. In the finished steel department, business has been on the quiet side, largely owing to the fact that the producing works are fully booked for a long period to come. Quiet conditions continue to rule in the export market, but lately there has been some increase in inquiry.

Scrap

Most consuming industries have their requirements of scrap fairly well covered for next year. Thus, imports are likely further to decline. Steelworks, especially, remain active buyers, and prices of suitable descriptions are fully maintained. Imports have ceased on the North-East Coast, but foreign supplies continue to arrive in large tonnages in South Wales, Scotland and other districts. The Executive Committee of the National Federation of Scrap Iron and Steel Merchants is to meet representatives of the British Iron and Steel Federation early in December in order to fix prices for 1938 and to review the working of the scrap agreement formulated earlier this year. It is considered unlikely that any price reductions will be made.

Metals

Copper.—The present demand for copper is insufficient to clear available supplies. Consumers continue to refrain from buying further quantities, but heavy tonnages are certain to be negotiated for directly conditions become more stable. The United States price was lowered from 12 cents to 11 cents per lb. on Tuesday, while later in the day 10¾ cents was quoted. The world's smelter output of copper in the July-September quarter of 1937 amounted to 392,700 short tons, according to the American Bureau of Metal Statistics, as compared with 431,100 tons in the second quarter and 396,500 tons in the first three months.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £38 2s. 6d. to £38 3s. 9d.; Friday, £37 11s. 3d. to £37 13s. 9d.; Monday, £37 11s. 3d. to £37 12s. 6d.; Tuesday, £37 to £37 2s. 6d.; Wednesday, £37 16s. 3d. to £37 18s. 9d.

Three Months.—Thursday, £38 8s. 9d. to £38 10s.; Friday, £37 16s. 3d. to £37 17s. 6d.; Monday, £37 16s. 3d. to £37 18s. 9d.; Tuesday, £37 5s. to £37 7s. 6d.; Wednesday, £38 1s. 3d. to £38 2s. 6d.

Tin.—This market continues to be very dull. Conditions in the United States also have been disappointing, and buying has been small. American tinplate mills are now operating at under 60 per cent. of capacity, while it is reported that the motor-car industry is not so satisfactory as had been anticipated. Speaking at the recent meeting of the London Nigerian Tin Mines, Mr. J. Ivan Spens, chairman, said that the directors remained firmly convinced that restriction was for the good of the tin industry as a whole. It was clear that no mere correlation of supplies to consumption would achieve stability in price. This support to the restriction scheme is in contrast to the criticism recently levelled against it by producers.

Official quotations were as follow :—

Cash.—Thursday, £181 10s. to £181 15s.; Friday, £183 to £183 10s.; Monday, £183 5s. to £183 15s.; Tuesday, £181 to £181 10s.; Wednesday, £186 to £186 10s.

Three Months.—Thursday, £181 10s. to £181 15s.; Friday, £183 to £183 5s.; Monday, £183 to £183 10s.; Tuesday, £180 10s. to £181; Wednesday, £185 15s. to £186.

Spelter.—The Metallgesellschaft reports that world output of spelter in September amounted to 134,400 metric tons. The total for the nine months of the year is 1,219,510 tons, against 1,108,057 tons in the corresponding period of 1936. The market has been quiet during the past week, and little business has been transacted.

Daily market prices :—

Ordinary.—Thursday, £15 12s. 6d.; Friday, £15 7s. 6d.; Monday, £15 5s.; Tuesday, £14 17s. 6d.; Wednesday, £15 5s.

Lead.—Figures issued by the Metallgesellschaft indicate that the world's smelter output of lead in September amounted to 136,216 metric tons. Output for the nine months of the year totalled 1,225,644 tons, as compared with 1,061,708 tons in the corresponding period of 1936. Rudolf Wolff & Company, in their weekly market report, state that lead has at times been well supported, and consuming interests have bought freely, but, nevertheless, prices have been brought down in sympathy with other markets and the easier tendency has in itself influenced a certain volume of selling and liquidation. Consumption in this country is reported to be satisfactorily maintained, but the setback in industrial conditions in the United States is viewed with some apprehension, and has a depressing influence on sentiment on this side.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £17; Friday, £16 13s. 9d.; Monday, £16; Tuesday, £16 2s. 6d.; Wednesday, £16 2s. 6d.

Scrap.—Consumers continue to purchase their requirements in only small tonnages. It is difficult to forecast the trend of prices, and buyers are not keen to deal at current figures, as they anticipate still lower levels. Good tonnages are likely to change hands as soon as prices show signs of rising.

Approximate selling prices for old metal:—New aluminium cuttings, £82; rolled, £67; cast, £40; foil, £94 to £98. Copper, £36 to £39; braziery, £35. Brass (clean), £25 to £27. Zinc, £10. Lead, £15. Gunmetal, £37 to £39.

Contracts Open

Stanley, December 6.—Provision and laying of about 1,050 yds. of 4-in. cast-iron pumping mains, for the Urban District Council. Taylor & Wallin, engineers, 1, Saville Place, Newcastle-upon-Tyne, 1. (Fee £5, returnable.)

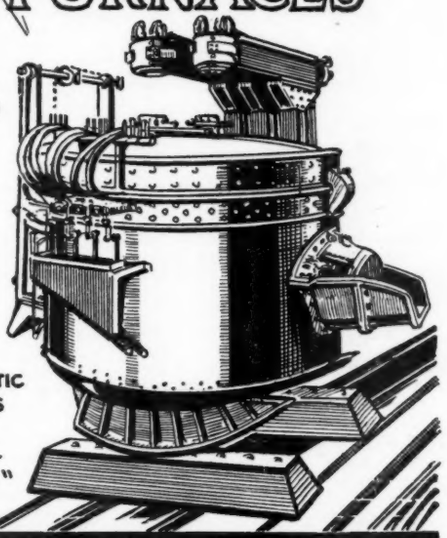
Sheppey, December 8.—Supply and erection of an electrically-driven borehole pumping plant of 3,000 galls. per hr. capacity, for the Rural District Council. Mr. E. F. Brading, surveyor, 395, Minster Road, Sheppey. (Fee £2 2s., returnable.)

Johannesburg, December 8.—Supply and erection of stone-crushing plant, including crushers, vibrating screen, conveying equipment and electric motors, etc., for the City Council. The Department of Overseas Trade. (Reference T.Y. 27,975/37.)

METALECTRIC

FOR MELTING IRON, STEEL AND ALLOYS

ELECTRIC FURNACES



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CORNWALL RD SMETHWICK BIRMINGHAM TEL. SMETHWICK. 1561 & 2

LONDON OFFICE ... 16 GROSVENOR PLACE, S.W.1.

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We cannot make Patterns

This is probably what would happen if we attempted to make an Engineers Pattern—but then—we are not Patternmakers; our speciality is Pattern VARNISH and ENAMELS—and we have been making them for half a century.

If you have adopted—or are contemplating changing over to—the sandslinging and vibration or the Randupson method of moulding, you should get into touch with us. These methods demand water-resistant Lacquers and Enamels of exceedingly hard gloss—specially designed to meet the rigorous conditions of modern moulding.

If we number you among our clients you will already know the qualities of our products—if not, let us send you samples—a halfpenny stamp, and the coupon below will bring them.

To Messrs. W. PICKARD & CO., LTD., SAXON WKS., RUTLAND RD., SHEFFIELD.

Please send samples of Pattern VARNISH.

Name.....

Address.....

.....

WARNER *Special* PIG IRONS

- *Warner C.B.R.*
- *and*
- *Low Carbon Cylinder*

(FOR CYLINDERS, ROLLS, ENGINEERING CASTINGS, ETC.)

- *Low Carbon Malleable*

(FOR MALLEABLE CASTINGS OF ALL DESCRIPTIONS)

Supplied to any specification between limits of 2·00 and 3·50% Carbon and ·50% and 3·50% Silicon

ACTUAL ANALYSIS CERTIFICATES ARE AVAILABLE WITH EACH DELIVERY

- **Typical Cylinder Pig Iron Specification**

TOTAL CARBON	2·70%
SILICON	1·80%
MANGANESE	·90%
SULPHUR	·06%
PHOSPHORUS	·40%

- **Typical Malleable Pig Iron Specification**

TOTAL CARBON	2·60%
SILICON	·75%
MANGANESE	·50%
SULPHUR	·05%
PHOSPHORUS	·06%

RNER & CO. LTD.
MIDDLESBROUGH

RAW MATERIALS—PRICE LIST

(Wednesday, November 24, 1937)

COPPER

	£	s.	d.
Standard cash	37	16	3
Three months	38	1	3
Electrolytic	42	0	0
Tough	41	15	0
Best selected	42	5	0
Sheets	75	0	0
India	52	12	6
Wire bars	43	10	0
Ingot bars	43	10	0
H.C. Wire rods	47	0	0
Off. av. cash, Oct.	45	8	9
Do., 3 mths., Oct.	45	12	11
Do., Sttlmnt., Oct.	45	8	9½
Do., Electro, Oct.	51	9	9½
Do., B.S., Oct.	51	17	6
Do., Wire bars, Oct.	52	7	1½
Solid drawn tubes			12½d.
Brazed tubes			12½d.
Wire			8½d.

BRASS

Solid drawn tubes	11d.
Brazed tubes	13d.
Rods, drawn	9½d.
Rods, extd. or rlld.	6½d.
Sheets to 10 w.g.	8½d.
Wire	8½d.
Rolled metal	8½d.
Yellow metal rods	6½d.

TIN

	£	s.	d.
Standard cash	186	0	0
Three months	185	15	0
English	186	0	0
Bars	188	0	0
Straits	189	0	0
Eastern	182	15	0
Banca (nom.)			—
Off. av. cash, Oct.	224	0	11⅜
Do., 3 mths., Oct.	223	9	10½
Do., Sttlmt., Oct.	224	1	10½

SPELTER

Ordinary	15	5	0
Remelted	12	17	6
Hard	12	7	6
Electro, 99.9	18	17	6
English	16	10	0
India	14	5	0
Zinc dust	23	0	0
Zinc ashes	5	5	0
Off. aver., Oct.	17	16	9½
Aver., spot, Oct.	17	14	5 3/14

LEAD

Soft foreign, ppt.	16	2	6
Empire (nom.)	17	0	0
English	18	0	0
Off. aver., Oct.	18	5	9½
Aver. spot, Oct.	18	5	2½

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

Zinc sheets, English	29	0	0 to 29 10 0
Do., V.M. ex-whse.	29	0	0 to 29 10 0
Rods	23	10	0

ANTIMONY

English	85	0	0 to 86 0 0
Chinese, ex-whse. (nom.)	72	0	0
Crude, c.i.f.	45	0	0

QUICKSILVER

Quicksilver	13	0	3

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	£14 10 0
45/50%	£12 0 0
75%	£17 0 0
Ferro-vanadium 35/50%	12/8 lb. Va.
Ferro-molybdenum— 70/75% carbon-free	4/9 lb. Mo.
Ferro-titanium— 20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 to £22
Ferro-tungsten— 80/85%	9/3 lb.
Tungsten metal powder— 98/99%	9/6 lb.
Ferro-chrome—	
2/4% car.	£34 15 0
4/6% car.	£24 5 0
6/8% car.	£24 0 0
8/10% car.	£24 0 0
Ferro-chrome—	
Max. 2% car.	£36 0 0
Max. 1% car.	£38 5 0
Max. 0.5% car.	£41 0 0
70% carbon-free	10d. lb.
Nickel—99.5/100%	£180 to £185
"F" nickel shot	£165 0 0
Ferro-cobalt, 98/99%	8/6 to 8/9 lb.
Metallic chromium— 96/98%	2/5 lb.
Ferro-manganese—	
76/80% loose	£18 15 0 to 19 5 0
76/80% packed	£19 15 0 to 20 5 0
76/80% export	£22 0 0
Metallic manganese— 94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 10d.
Finished bars, 18% tungsten	5s. 0d.

Per lb. d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ¼ in. to ⅛ in.	3d. lb.
Do., under ⅛ in. to 1/16 in.	1/- lb.
Flats, ¼ in. × ⅛ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ⅛ in. × ⅛ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.	£	s.	d.
South Wales (West)—						
Heavy steel, best	3	8	6	to 3	11	0
Mixed iron and steel	3	6	0	to 3	8	6
Heavy cast iron	3	8	6	to 3	11	0
Good machinery			3	17	6	
Cleveland—						
Heavy steel, best	3	7	0	to 3	9	6
Steel turnings	2	13	0	to 2	15	6
Heavy cast iron			4	5	0	
Heavy machinery			4	10	0	
Midlands—						
Short heavy steel			4	0	0	
Light cast-iron scrap	3	2	6	to 3	5	0
Heavy wrought iron	4	0	0	to 4	5	0
Steel turnings	2	5	6	to 2	8	0
Scotland—						
Heavy steel, best	3	5	0	to 3	7	6
Ordinary cast iron	4	7	6	to 4	10	0
Cast-iron borings	2	0	0	to 2	2	6
Wrot-iron piling			4	17	6	
Heavy machinery	4	15	0	to 4	17	6

London—Merchants' buying prices, delivered yard.

Copper (clean)	30	0	0
Brass	21	10	0
Lead (less usual draft)	14	0	0
Tea lead	11	10	0
Zinc	8	10	0
New aluminium cuttings	71	0	0
Braziery copper	27	0	0
Gunmetal	30	0	0
Hollow pewter	125	0	0
Shaped black pewter	89	0	0

PIG-IRON*

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	108/6
,, No. 3	106/-
,, No. 4	105/-
Forge No. 4	105/-
Hematite No. 1	123/-
Hematite M/Nos.	122/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	123/-
,, d/d Birm.	134/6
Malleable iron d/d Birm.	160/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	108/-
,, No. 3 fdry.	111/-
Northants forge	105/6
,, fdry. No. 3	108/6
,, fdry. No. 1	111/6
Derbyshire forge	108/-
,, fdry. No. 3	111/-
,, fdry. No. 1	114/-
Scotland—	
Foundry, No. 1, f.o.t.	120/6
,, No. 3, f.o.t.	118/-
Cleveland No. 3, Glasgow	112/-
,, ,, Falkirk	109/-
Scottish hem. M/Nos. d/d	123/-
Sheffield (d/d district)—	
Derby forge	105/6
,, fdry. No. 3	108/6
Lincs forge	105/6
,, fdry. No. 3	108/6
W.C. hematite	128/6
Lancashire (d/d eq. Man.)—	
Derby fdry, No. 3	114/-
Staffs fdry. No. 3	114/-
Northants fdry. No. 3	112/6
Cleveland fdry. No. 3	114/-
Glengarnock, No. 3	140/-
Clyde, No. 3	140/-
Monkland, No. 3	140/-
Summerlee, No. 3	140/-
Eglinton, No. 3	140/-
Gartsherrie, No. 3	140/-
Shotts, No. 3	140/-

(* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.)

FINISHED IRON AND STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	13	5	0	to 13	15	0
Nut and bolt iron	11	12	6	to 12	2	6
Hoops				14	2	6
Marked bars (Staffs) f.o.t.				15	15	0
Gas strip				14	2	6
Bolts and nuts, ¾ in. × 4 in.				17	10	0 and up.
Steel—						
Plates, ship, etc.	11	8	0	to 11	10	6
Boiler plts.	11	18	0	to 12	0	6
Chequer plts.				13	0	6
Angles				11	0	6
Tees				12	0	6
Joists				11	0	6
Rounds and squares, 3 in. to 5½ in.				12	0	6
Rounds under 3 in. to ⅜ in. (Untested)				11	9	0
Flats—8 in. wide and over				11	5	6
,, under 8 in. and over 5 in.				11	10	6
Rails, heavy				10	2	6
Fishplates				14	2	6
Hoops (Staffs)				12	4	0
Black sheets, 24g. (4-t. lots)				15	15	0
Galv. cor. shts. (,,)				19	10	0
Galv. flat shts. (,,)				20	0	0
Galv. fencing wire, 8g. plain				20	5	0
Billets, soft, 100-ton lots				7	17	6
Sheet bars				7	15	0
Tin bars				7	15	0

PHOSPHOR BRONZE

	Per lb. basis
Strip	11d.
Sheet to 10 w.g.	11½d.
Wire	12½d.
Rods	13½d.
Tubes	18½d.
Castings	15½d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop. £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	8d. to 1/2
Rolled—	
To 9 in. wide	1/2 to 1/8
To 12 in. wide	1/2½ to 1/8½
To 15 in. wide	1/2½ to 1/8½
To 18 in. wide	1/3 to 1/9
To 21 in. wide	1/3½ to 1/9½
To 25 in. wide	1/4 to 1/10
Ingots for spoons and forks	8d. to 1/4½
Ingots rolled to spoon size	11d. to 1/7½
Wire round—	
to 10g.	1/5½ to 2/0½

with extras according to gauge.

Special 5ths quality turning rods in straight lengths, 1/4½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.76
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	102.50
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.25
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	3.15
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb. box	$5.35

COKE (at ovens)

Welsh foundry	42/6
,, furnace	37/6
Durham foundry	38/6
,, furnace	37/6
Scottish foundry	42/6
,, furnace	40/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	23/- to 24/-	
,,	28×20 ,,	46/- to 48/-	
,,	20×10 ,,	35/6 to 36/-	
,,	18¾×14 ,,	25/6 to 26/-	
C.W.	20×14 ,,	20/6 to 21/6	
,,	28×20 ,,	41/- to 42/6	
,,	20×10 ,,	31/- to 31/6	
,,	18¾×14 ,,	22/- to 22/6	

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£12	0	0	to £13	0	0
Bars-hammered, basis	£20	0	0	to £22	0	0
Bars and nail-rods, rolled, basis	£19	0	0	to £20	0	0
Blooms	£18	0	0	to £19	0	0
Keg steel	£30	0	0	to £35	0	0
Faggot steel	£20	0	0	to £25	0	0
Bars and rods dead soft st'l	£19	0	0	to £20	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£ s. d.	
Nov. 18 ..	38 2 6 dec.	25/-
„ 19 ..	37 11 3 „	11/3
„ 22 ..	37 11 3 No	change
„ 23 ..	37 0 0 dec.	11/3
„ 24 ..	37 16 3 inc.	16/3

Electrolytic Copper

	£ s. d.	
Nov. 18 ..	43 0 0 dec.	20/-
„ 19 ..	42 0 0 „	20/-
„ 22 ..	42 0 0 No	change
„ 23 ..	41 10 0 dec.	10/-
„ 24 ..	42 0 0 inc.	10/-

Standard Tin (cash)

	£ s. d.	
Nov. 18 ..	181 10 0 dec.	130/-
„ 19 ..	183 0 0 inc.	30/-
„ 22 ..	183 5 0 „	5/-
„ 23 ..	181 0 0 dec.	45/-
„ 24 ..	186 0 0 inc.	100/-

Tin (English ingots)

	£ s. d.	
Nov. 18 ..	181 10 0 dec.	130/-
„ 19 ..	183 0 0 inc.	30/-
„ 22 ..	183 5 0 „	5/-
„ 23 ..	181 0 0 dec.	45/-
„ 24 ..	186 0 0 inc.	100/-

Spelter (ordinary)

	£ s. d.	
Nov. 18 ..	15 5 0 dec.	17/6
„ 19 ..	15 7 6 inc.	2/6
„ 22 ..	15 5 0 dec.	2/6
„ 23 ..	14 17 6 „	7/6
„ 24 ..	15 5 0 inc.	7/6

Spelter (Electro, 99.9 per cent.)

	£ s. d.	
Nov. 18 ..	18 16 3 dec.	18/9
„ 19 ..	19 0 0 inc.	3/9
„ 22 ..	18 16 3 dec.	3/9
„ 23 ..	18 10 0 „	6/3
„ 24 ..	18 17 6 inc.	7/6

Lead (soft foreign, prompt)

	£ s. d.	
Nov. 18 ..	17 0 0 dec.	6/3
„ 19 ..	16 13 9 „	6/3
„ 22 ..	16 0 0 „	13/9
„ 23 ..	16 2 6 inc.	2/6
„ 24 ..	16 2 6 No	change

Lead (English)

	£ s. d.	
Nov. 18 ..	19 0 0 dec.	10/-
„ 19 ..	18 15 0 „	5/-
„ 22 ..	18 0 0 „	15/-
„ 23 ..	18 0 0 No	change
„ 24 ..	18 0 0 „	„

A COMPARISON OF SCRAP PRICES

Prices of Heavy Steel Scrap (Delivered) in the Principal Districts at the Beginning of Each Month in the Years 1930–1937.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Scotland—													
1930	3 9 0	3 7 6	3 5 0	3 5 0	3 0 6	2 15 0	2 12 0	2 10 0	2 13 3	2 10 0	2 10 0	3 10 6	3 13 1½
1931	2 7 6	2 7 6	2 5 0	2 5 0	2 0 0	1 17 6	1 17 6	1 17 6	1 17 6	1 15 0	2 0 0	2 10 0	2 17 3½
1932	2 2 6	2 2 6	2 0 0	1 17 6	1 17 6	1 17 6	1 15 0	1 15 0	1 12 6	1 13 0	1 12 6	2 2 6	2 1 0½
1933	1 15 0	1 17 6	1 18 6	1 18 9	1 18 0	1 17 6	1 18 9	2 0 0	2 2 6	2 5 0	2 7 6	1 15 0	1 16 9½
1934	2 8 9	2 14 3	2 13 0	2 13 0	2 12 0	2 10 0	2 10 6	2 10 6	2 11 0	2 10 9	2 10 0	2 8 9	2 0 7½
1935	2 10 0	2 10 0	2 10 0	2 10 0	2 10 0	2 10 0	2 10 0	2 10 0	2 10 0	2 10 0	2 10 0	2 10 0	2 11 2
1936	2 12 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 1
1937	2 17 6	3 2 6	3 6 0	3 5 9	3 5 9	3 5 9	3 5 9	3 5 9	3 5 9	3 5 9	3 6 3	—	—
North-East Coast—													
1930	3 3 6	3 3 6	3 2 0	3 0 0	2 17 6	2 10 0	2 10 0	2 7 6	2 7 6	2 7 6	2 5 0	2 6 0	2 13 4
1931	2 6 0	2 6 0	2 5 0	2 5 0	2 2 6	2 0 0	1 17 6	1 17 6	1 17 6	1 17 6	1 17 6	2 2 6	2 1 2½
1932	2 0 0	2 0 0	1 15 0	1 15 0	1 15 0	1 15 0	1 15 0	1 15 0	1 15 0	1 12 6	1 15 0	1 17 6	1 15 10
1933	2 0 0	2 0 0	2 5 0	2 0 0	1 15 0	1 17 6	2 2 6	2 2 6	2 3 6	2 5 0	2 7 6	2 7 6	2 2 2
1934	2 10 0	2 16 0	2 10 0	2 7 6	2 7 6	2 10 0	2 9 9	2 10 0	2 10 0	2 10 0	2 11 6	2 11 3	2 10 3½
1935	2 11 6	2 11 9	2 12 0	2 12 0	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 13 9	2 12 4½
1936	2 15 0	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	3 0 0	3 0 0	2 17 8½
1937	3 2 6	3 5 0	3 7 0	3 7 9	3 7 9	3 7 9	3 7 9	3 7 9	3 7 9	3 7 9	3 8 3	—	—
South Wales—													
1930	3 7 6	3 6 0	3 6 0	3 4 0	3 2 6	2 17 6	2 16 0	2 15 0	2 14 9	2 12 6	2 12 6	2 5 0	2 18 3½
1931	2 5 0	2 7 6	2 7 6	2 7 6	2 5 0	2 2 6	2 0 0	2 0 0	1 18 0	2 2 6	2 5 0	2 7 6	2 4 0
1932	2 6 6	2 6 0	2 5 0	2 2 6	2 2 0	1 19 0	1 17 6	1 18 6	1 18 0	1 18 0	1 17 6	1 18 0	2 0 8½
1933	2 0 0	2 1 6	2 4 0	2 3 6	2 3 6	2 3 0	2 5 0	2 5 0	2 8 0	2 10 0	2 10 0	2 10 0	2 5 3½
1934	2 10 0	2 16 3	2 15 9	2 13 9	2 14 3	2 15 0	2 14 3	2 14 3	2 15 0	2 15 6	2 15 6	2 15 6	2 14 7
1935	2 15 6	2 15 6	2 15 6	2 15 6	2 15 6	2 15 6	2 15 6	2 15 6	2 16 1½	2 17 9	2 19 8	3 1 1½	2 16 2½
1936	3 2 6	3 5 0	3 5 0	3 5 0	3 5 0	3 5 0	3 3 0	3 2 0	3 2 0	3 4 0	3 4 0	3 4 0	3 3 10½
1937	3 5 0	3 10 0	3 10 0	3 8 9	3 8 9	3 8 9	3 8 9	3 8 9	3 8 9	3 9 9	3 9 9	—	—

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FIRST-CLASS Moulder, green, dry sand, seeks situation. Three years' experience assistant foreman, jobbing, repetition, ordinary, high-duty cast irons. Young, keen, energetic. Guaranteed to get results.—Box 688, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

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EMPLOYMENT REGISTER.

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FOUNDRY Foreman with thoroughly practical training and experience requires re-engagement. Experience includes general engineering castings up to 20 tons, also repetition work, machine and plate (315)

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'Phone **98** Staines.

C.I. Sectional Tank, 27 ft. by 12 ft. by 9 ft.
Air Receiver, 19 ft. 6 in. by 3 ft., for 100 lbs. w.p.
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30-h.p. ditto; 12-in. outlet.
5-h.p. ditto; 6-in. outlet.
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New O.T. self-colour CISTERNS, 4′ x 4′ x 4′, 400 galls.
Four "Hotchkiss" Feed-water CIRCULATORS.
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SAND MIXERS AND AERATORS.—The "Breakir" Centrifugal Machine is *THE* machine. Outputs 10 cwts. to 8 tons per hr.—W. BREALEY & Co., LTD., Station Works, Ecclesfield, Sheffield.

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SILVER SAND for your coremaking, delivered in works. Inquiries invited.—H. O. ANDREW & Co., Silver Sand Quarries, Ketton, near Stamford, Lincs.

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FLUIDITY TESTS.—Patterns for these tests as described in F.T.J. of September 24, 1936, by Carl F. Joseph. Made in aluminium from our master pattern. 35s. per set. We shall also be glad to have your inquiries for patterns in hard or soft woods for all kinds of engineering, large and small.—FURMSTON & LAWLOR, Pattern Makers, Letchworth.

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